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RESEARCH

A retrospective cohort study of the oral healthcare needs of cancer patients

Sophie Beaumont[1,2] · **Aimee Liu**[3] · **Katrusha Hull**[1]

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Abstract

Purpose Oral health and its impact on general well-being is acutely evident with a cancer diagnosis. Most cancer treatments will affect the oral environment, with poor oral health having the potential to negatively impact cancer treatment outcomes.

Methods This retrospective study included 1500 patients referred for dental examination prior to cancer therapy at the Peter MacCallum Cancer Centre, Australia, between January 2017 and August 2019. Demographic characteristics, cancer diagnosis, and baseline oral health information were recorded.

Results Patients were referred from the head and neck tumour stream (56%), haematology (27.7%), breast and genitourinary (6.1%), and others (9.7%). Of the patients who required dental treatment 49% required a dental extraction prior to their cancer treatment to optimise oral health. Head and neck cancer patients presented with poorer oral hygiene and required more dental extractions than other patient groups ($\chi^2 = 17.59$, $p = 0.00003$).

Conclusions Baseline oral health for cancer patients was below expected compared with the Australian average. Dental treatment was necessary for more than half of patients to reduce infection risk and improve function and quality of life during and following cancer treatment, highlighting the essential role of oral health clinicians in the multidisciplinary team.

Keywords Oral health · Multidisciplinary care · Dental extractions · Head and neck cancer

Introduction

Untreated disease within the oral cavity has the potential to complicate cancer therapy, in some cases leading to its interruption, increasing morbidity, and prolonged hospitalisation [1]. Surprisingly, it is estimated that as many as 97% of all cancer patients require some form of oral health care prior to commencement of their cancer treatment [2] as orofacial complications and treatment toxicities are common [3]. A comprehensive oral examination prior to the commencement of cancer therapy is therefore essential to minimise the risk of such complications [1, 4–6].

A thorough understanding of the expected oral and dental side effects associated with the planned cancer therapy is essential when planning dental treatment. The goals of treatment, curative versus palliative, must also be considered alongside patient motivation and past dental behaviours. Treatment priorities include the elimination of dental infection and optimisation of oral health prior to cancer therapy, whilst elective and restorative treatment may be delayed if necessary [7]. Coordination with the medical team is critical in the safe delivery of dental treatment to achieve the best outcomes.

Comprehensive dental care includes recording baseline oral health status and utilising imaging techniques such as CBCTs, orthopantomograms (OPGs), and intra-oral radiographs to identify and address infection risks before cancer treatment. Immediate goals include extracting compromised teeth and stabilising the dentition. Dentists also play a crucial role in counselling patients on tobacco and alcohol cessation, dietary modifications to reduce sugar intake, and educating them on the impact of these factors on oral health and cancer recurrence. Ongoing maintenance through regular

✉ Aimee Liu
aimee.liu27@gmail.com

[1] Peter MacCallum Cancer Centre, 305 Grattan Street, Melbourne 3000, Australia

[2] Royal Dental Hospital of Melbourne, 720 Swanston Street, Carlton, Victoria 3053, Australia

[3] Monash Health, 246 Clayton Road, Clayton, Victoria 3168, Australia

oral hygiene monitoring and early detection of recurrent disease is essential to optimise long-term oral health.

Cancer therapies can exacerbate pre-existing oral health issues and predispose patients to a range of oral complications. The Dental Oncology Department of the Peter MacCallum Cancer Centre examines patients from all tumour streams prior to initiation of cancer therapy to determine dental fitness. A dental and oral assessment is recommended for patients prior to commencing treatment with (1) head and neck radiotherapy (RT) [8–13], (2) bone-modifying agents (BMAs) that modify bone metabolism or angiogenesis [14, 15], and (3) haematopoietic stem cell transplantation (HSCT) [2, 16, 17].

The primary aims of this study were (1) to summarise the demographics of cancer patients referred for dental assessment and (2) to compare their baseline oral and dental health with the general Australian population. The secondary aims were to explore essential dental treatments required before comprehensive cancer care.

Materials and methods

Ethics approval

This retrospective study was conducted at the Peter MacCallum Cancer Centre. The ethical consent regarding this study protocol was received from the Peter MacCallum Cancer Centre (HREC reference PMCC19/142R version 3, 11/05/2021). This study was conducted in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Study design and inclusion/exclusion criteria

Cancer patients were eligible for inclusion if they attended the Dental Oncology department between January 2017 and July 2019 and were over 18 years of age. Participants were excluded if they were missing key demographic information required for the study objectives were missing in the electronic medical record (EMR).

Patient demographics and dental practices

Data collection included patient demographics, cancer diagnosis, medical history, medications, and lifestyle factors such as smoking and alcohol consumption. Tobacco use was categorised as current, previous, or never, whilst alcohol consumption was recorded as either yes or no. Dental attendance patterns were classified as favourable (within the past 12 months) or unfavourable (beyond 12 months) based on the 2017–2018 National Study of Adult Oral Health guidelines [18]. In addition, the type of dental practice attended, either private (self-funded) or public (eligibility-based), was documented.

Clinical parameters

Oral hygiene was categorised as good (minimal plaque on all surfaces), moderate (plaque on several surfaces), or poor (thick plaque deposits on all teeth) [19]. Periodontal status was classified as good (no bone loss), moderate (10–40% bone loss), or poor (greater than 40% bone loss) based on CBCT findings using criteria modified from the World Workshop on Periodontal and Peri-Implant Diseases [20]. Inadequate dentition at the initial consultation was defined as having 20 or fewer teeth, following Australia Institute Health and Welfare AIHW guidelines [21]. The number of teeth requiring extraction before cancer therapy was also recorded.

Statistical analysis

All statistical analyses were performed in R (version 3.6.3 (2020–02–29)) by the Biostatistics and Clinical Trials department of the Peter MacCallum Cancer Centre. Descriptive statistics were employed to summarise patient demographics and clinical characteristics. Proportions were calculated for categorical variables, whilst continuous variables were reported as means and standard deviations. Chi-square tests were employed to assess differences in oral health outcomes among cancer types, with significance set at $p < 0.05$.

Results

After applying the inclusion/exclusion criteria, a total of 1500 patient files were assessed, included and reviewed in the defined date range and streamed by type of malignancy. Table 1 summarises the data on patient demographics, comorbidities, medications and alcohol/tobacco history, whilst Table 2 summarises oral and dental health information.

Demographics

Head and neck cancer (HNC) was the most common underlying malignancy, accounting for 56% of all cancer patients assessed. This was followed by those with haematological malignancies (28%), breast cancer (4.5%), genitourinary cancers (1.6%), and others (9.7%). Across the entire patient cohort, there was a strong male predominance (68%, $n = 1021$), which was especially apparent in the head and neck tumour stream (75%), and to a lesser degree in the haematology group (64%). The mean age within the cohort was 61 years (SD = 14), with the lowest mean age observed in the breast tumour stream (mean 56, SD = 11) and highest in

Table 1 Patient demographics according to tumour stream

Characteristic	Tumour stream					
	H&N ($n=846$)	Haematology ($n=416$)	Breast ($n=68$)	Genitourinary ($n=24$)	Other ($n=146$)	Total ($n=1500$)
Age, years						
Mean (SD)	63 (13)	59 (13)	56 (11)	63 (16)	62 (18)	61 (14)
Median [range]	62 [19–95]	62 [18–87]	57 [30–78]	67 [29–87]	62 [17–95]	62 [17–95]
Gender						
Male	634 (75%)	268 (64%)	1 (1%)	23 (96%)	95 (65%)	1021 (68%)
Female	212 (25%)	148 (36%)	67 (99%)	1 (4%)	51 (35%)	479 (32%)
Medications‡						
Other	657 (78%)	339 (81%)	62 (91%)	19 (79%)	124 (85%)	1201 (80%)
Antihypertensive	282 (33%)	113 (27%)	13 (19%)	11 (46%)	48 (33%)	467 (31%)
Anticoagulant	142 (17%)	88 (21%)	12 (18%)	6 (25%)	34 (23%)	282 (19%)
Statins	139 (16%)	56 (13%)	8 (12%)	4 (17%)	27 (18%)	234 (16%)
Immunosuppressive	56 (7%)	54 (13%)	4 (6%)	4 (17%)	12 (8%)	130 (9%)
Insulin ± metformin	52 (6%)	25 (6%)	7 (10%)	2 (8%)	10 (7%)	96 (6%)
Comorbidities‡						
Hypertension	319 (38%)	126 (30%)	13 (19%)	10 (42%)	56 (38%)	524 (35%)
Hypercholesterolemia	146 (17%)	56 (13%)	3 (4%)	5 (21%)	30 (21%)	240 (16%)
Gastric reflux	116 (14%)	86 (21%)	2 (3%)	1 (4%)	28 (19%)	233 (16%)
Heart conditions	108 (13%)	50 (12%)	4 (6%)	5 (21%)	33 (23%)	200 (13%)
Diabetes	84 (10%)	40 (10%)	9 (13%)	4 (17%)	19 (13%)	156 (10%)
Mental health conditions	68 (8%)	46 (11%)	11 (16%)	3 (12%)	15 (10%)	143 (10%)
Asthma or breathing disorders	60 (7%)	20 (5%)	3 (4%)	0	7 (5%)	90 (6%)
Osteoporosis	22 (3%)	15 (4%)	7 (10%)	1 (4%)	6 (4%)	51 (3%)
Liver disease or hepatitis	18 (2%)	7 (2%)	0	0	2 (1%)	27 (2%)
Organ transplant	5 (1%)	20 (5%)	0	0	1 (1%)	26 (2%)
Neurological disease	5 (1%)	10 (2%)	0	0	5 (3%)	20 (1%)
Bleeding disorders	4 (0%)	4 (1%)	0	0	0	8 (1%)
Smoking history						
Previous	380 (48%)	159 (42%)	22 (36%)	11 (46%)	57 (47%)	629 (46%)
Never	275 (35%)	198 (52%)	35 (57%)	11 (46%)	50 (41%)	569 (42%)
Current	130 (17%)	23 (6%)	4 (7%)	2 (8%)	14 (12%)	173 (13%)
Missing	61	36	7	0	25	129
Alcohol						
Current			261 (62%)	61 (53%)	7 (35%)	3 (38%)
Never			120 (29%)	46 (40%)	13 (65%)	4 (50%)

‡More than one option may have been selected

both the HNC cohort (mean 63, SD = 13) and genitourinary cohort (mean 63, SD = 16).

Risk factors

Across the entire cohort, most patients reported a smoking history (59%) with 13% ($n=173$) identifying as current smokers and a further 46% ($n=629$) as past smokers. Among HNC patients, 48% were previous smokers, 35% had never smoked, and 17% were current smokers. A statistically significant higher prevalence of smoking (former or current) was observed in HNC patients compared with to those haematological malignancies or breast cancer ($\chi^2=14.00$, $p=0.00731$). Alcohol was also identified as an important risk factor, with 62% of HNC patients report current alcohol use, which is considerably higher when compared with 35% in the breast cancer and 53% in the haematology groups.

Table 2 Oral health characteristics by tumour stream

Characteristic	Tumour stream					
	H&N ($n=846$)	Haematology ($n=416$)	Breast ($n=68$)	Genitourinary ($n=24$)	Other ($n=146$)	Total ($n=1500$)
Oral health						
Moderate	376 (48%)	166 (43%)	20 (33%)	13 (65%)	66 (50%)	641 (46%)
Good	230 (29%)	174 (45%)	24 (40%)	3 (15%)	24 (18%)	455 (33%)
Poor	180 (23%)	44 (11%)	16 (27%)	4 (20%)	42 (32%)	286 (21%)
Missing data field	60	32	8	4	14	118
Dental attendance previous 12 months						
No	438 (53%)	175 (43%)	40 (60%)	11 (46%)	81 (56%)	745 (50%)
Yes	396 (47%)	235 (57%)	27 (40%)	13 (54%)	64 (44%)	735 (50%)
Missing data field	12	6	1	0	1	20
Type of dental clinic						
Private	486 (57%)	277 (67%)	32 (47%)	9 (38%)	79 (54%)	883 (59%)
Public	214 (25%)	82 (20%)	20 (29%)	13 (54%)	42 (29%)	371 (25%)
Unknown	146 (17%)	57 (14%)	16 (24%)	2 (8%)	25 (17%)	246 (16%)
Periodontal status						
Moderate	370 (49%)	136 (37%)	24 (41%)	7 (37%)	62 (49%)	599 (45%)
Good	265 (35%)	193 (53%)	21 (36%)	7 (37%)	41 (33%)	527 (40%)
Poor	113 (15%)	38 (10%)	14 (24%)	5 (26%)	23 (18%)	193 (15%)
Missing	98	49	9	5	20	181
Hyposalivation						
No	581 (75%)	307 (82%)	38 (68%)	17 (77%)	100 (78%)	1043 (77%)
Yes	194 (25%)	66 (18%)	18 (32%)	5 (23%)	28 (22%)	311 (23%)
Missing	71	43	12	2	18	146
Dental prosthesis[‡]						
None	550 (65%)	289 (69%)	36 (53%)	14 (58%)	102 (70%)	991 (66%)
Removable dentures	233 (28%)	99 (24%)	19 (28%)	9 (38%)	37 (25%)	397 (26%)
Fixed prosthesis	43 (5%)	20 (5%)	13 (19%)	1 (4%)	5 (3%)	82 (5%)
Implants	25 (3%)	7 (2%)	3 (4%)	0	0	35 (2%)
Number of teeth present at initial assessment						
Mean (SD)	20 (9)	23 (8)	21 (8)	20 (9)	20 (8)	21 (8)
Median [range]	23 [0–32]	26 [0–32]	24 [0–32]	22 [0–32]	22 [0–32]	24 [0–32]
IQR	15–27	20–28	18–27	16–27	15–27	16–28
>20	508 (60%)	306 (74%)	44 (65%)	13 (54%)	85 (58%)	956 (64%)
≤ 20	338 (40%)	109 (26%)	24 (35%)	11 (46%)	61 (42%)	543 (36%)
Missing	0	1	0	0	0	1
Teeth indicated for extraction						
No	402 (48%)	259 (62%)	31 (46%)	8 (33%)	62 (42%)	762 (51%)
Yes	444 (52%)	157 (38%)	37 (54%)	16 (67%)	84 (58%)	738 (49%)
Teeth extraction status						
Had extraction	363 (82%)	142 (90%)	32 (86%)	15 (94%)	70 (83%)	622 (84%)
Lost to follow-up[†]	81 (18%)	15 (10%)	5 (14%)	1 (6%)	14 (17%)	116 (16%)
Number of teeth extracted						
Mean (SD)	2 (4)	0 (1)	0 (1)	0 (0)	1 (2)	1 (3)
Median [range]	0 [0–29]	0 [0–14]	0 [0–7]	0 [0–0]	0 [0–17]	0 [0–29]
IQR	0–2	0–0	0–0	0–0	0–0	0–1
<3	687 (81%)	415 (100%)	67 (99%)	24 (100%)	135 (92%)	1328 (89%)
≥ 3	159 (19%)	1 (0%)	1 (1%)	0	11 (8%)	172 (11%)

[‡]More than one option may have been selected

[†]All patients indicated for extraction who never returned for the extraction are considered lost to follow-up

Oral health status

At the time of examination, 36% of patients ($n = 543$) presented with an inadequate dentition (less than or equal to 20 teeth [19]), significantly higher than the general Australian population (10%) ($\chi^2 = 25.84$, $p < 0.0001$). The highest proportion was seen in the genitourinary cancer stream (46%) followed HNC cohort (40%), both of which were statistically higher compared to patients with haematological malignancy or breast cancer ($\chi^2 = 22.80$, $p < 0.0001$). Periodontal disease was also prevalent, with 60% of patients presenting with moderate-to-severe periodontitis, double the 30% reported in the Australian adult population as reported by the Australian National Study of Adult Oral Health (2017–2018) [18]. Moderate or severe periodontitis was significantly less common (47%) in patients with an underlying haematological malignancy ($\chi^2 = 34.24$, $p < 0.0001$) compared to other cancer cohorts (HNC = 64%, breast cancer = 65%, and genitourinary cancers = 63%). HNC patients had a mean of 20 teeth at initial assessment (SD = 9), which was lower than the haematology group (mean = 23, SD = 8). Furthermore, hyposalivation was reported in 23% of all cancer patients, with the highest prevalence in breast cancer patients (32%), followed by HNC patients (25%) and genitourinary cancer patients (23%), while haematology patients had the lowest prevalence (18%).

Dental practices

Half of the patients (50%) reported visiting a dentist in the past year, comparable to the 56% nationally [18]. However, the majority (59%) attended private dental practices, which is lower than the national average of 82%. Patients with haematological malignancies had better baseline oral health compared to other cancer groups, with the highest number of teeth at initial consultation (mean 23, SD = 8) and the highest rate of regular dental attendance (57%). In contrast, only 26% of haematology patients had inadequate dentition, compared to 40% of head and neck cancer (HNC) patients. Breast cancer patients had the lowest dental attendance rate (40%), followed by HNC patients (47%).

Dental extractions

Nearly half (49%) of patients required dental extractions before cancer therapy, with an overall average of one tooth per patient (SD = 3). HNC patients had the highest extraction needs, averaging two teeth per patient (SD = 4), which was significantly more than other cancer streams ($\chi^2 = 17.59$, $p < 0.0001$). Overall, 84% of patients who required dental extractions returned for treatment, with 16% lost to follow-up. Compliance with recommended treatment was slightly lower among HNC (82%) than for other cohorts (haematology = 90%, breast = 86%, genitourinary = 94%).

Discussion

Our findings underscore the importance of integrating dental care in cancer management, as baseline oral health status was poorer in cancer patients than the general population, particularly in HNC patients. Cancer therapies such as chemotherapy, radiotherapy, and bone-modifying agents can exacerbate pre-existing oral health issues and predispose patients to a range of oral complications. By identifying and addressing these issues early, clinicians can reduce the risk of treatment-related toxicities and improve patient outcomes and quality of life.

Oral health disparities are more pronounced among Australians in lower socio-economic groups and those with chronic diseases [22], including cancer. National data indicate that approximately 20% of Australian adults delay or avoid dental care due to financial constraints [21], which may contribute to the poor oral health observed in cancer patients. In our cohort, 50% of patients had not visited a dentist in the past year. As a public cancer hospital, the Peter MacCallum Cancer Centre primarily serves patients without private health insurance, which may partially explain the lower baseline oral health. Patients without private insurance may face greater challenges in accessing regular preventative dental care, which may exacerbate oral health problems by the time they present for cancer treatment, further complicating their care.

Head and neck radiotherapy

Dentists play a crucial role in the long-term care of HNC patients by managing modifiable risks, such as tobacco use, alcohol consumption and areca nut chewing, all of which contribute to cancer recurrence and poor oral health. Prophylactic dental interventions prior to radiotherapy, combined with consistent post-treatment maintenance, are essential given the elevated risk of severe oral complications following head and neck radiotherapy. This includes osteoradionecrosis (ORN), which is commonly precipitated by invasive dental procedures such as extractions [23].

One significant finding of this study was the high prevalence of poor oral health among HNC patients, which was markedly worse compared to the general Australian population. Rupe et al. [24] reported similar findings, with 74.9% of HNC patients presenting with poor oral health

(Decayed, Missing and Filled Teeth index (DMFT) ≥ 13 and severe periodontitis) before radiotherapy. Sahingur and Yeudall [25] highlighted the connection between chronic periodontal inflammation and cancer progression, noting that chemokines involved in periodontal disease may promote tumour growth and metastasis. In addition, periodontal pathogens such as *Porphyromonas gingivalis* can modulate immune responses and enhance the malignant phenotype of oral epithelial cells. Regarding extractions, adherence was notably lower among HNC patients (82%) compared with other tumour streams. This is concerning given the importance of pre-treatment extractions in this group to prevent the serious late toxicity of ORN.

HNC patients often face significant socioeconomic barriers that hinder their access to comprehensive dental care. In this study, while 47% of HNC patients reported visiting a dental clinic in the past 12 months, many soughed care at public dental services, which cater to lower socioeconomic groups and have limited access to specialised care. This is further compounded by risk factors such as smoking and alcohol consumption, both of which were significantly more prevalent in HNC patients. Kovarik et al. [26] highlighted that financial constraints and the lack of access to specialised dental care contribute to high rates of post-radiotherapy dental complications, emphasising the need for better integration of dental services into oncology care. The higher proportion of HNC patients who seek public dental care highlights an association between low socio-economic status, poor dental health, tobacco consumption and cancer risk, all of which are associated with higher risk of tooth loss [27].

Patients with HNC experience significant long-term dental complications following radiotherapy, with studies documenting an increase in caries and tooth loss over time. Brennan et al. [22] reported a steady rise in the Decayed, Missing and Filled Surfaces (DMFS) index over two years post-radiotherapy, identifying modifiable risk factors such as fluoride use, oral hygiene practices and dental follow-ups to help mitigate these effects. In addition, Gomes-Silva et al. [28] found that the risk of tooth loss was three times higher when teeth were exposed to radiation doses above 60 Gy, with a significant increase in ORN at doses exceeding 50 Gy.

Structured oral care programs have a crucial role in mitigating the adverse effects of radiotherapy. Sohn et al. [29] demonstrated that patients who received regular professional dental care, including fluoride application, periodontal maintenance and patient education, had significantly better periodontal health and lower rates of complications. The OraRad study by Brennan et al. [22] found that non-compliance with oral hygiene recommendations was a key predictor of tooth failure within two years of radiotherapy. This emphasises the need for continuous patient education and follow-up to ensure adherence to preventive care measures.

Anti-resorptive therapy/bone-modifying agents (BMA)

Patients with breast and genitourinary malignancies patients face an increased risk of medication-related osteonecrosis of the jaw (MRONJ) due to prolonged use of bone-modifying agents (BMAs), hence the need for pre-treatment dental assessment and management. In this cohort, dental attendance rates were low, with only 40% of breast cancer and 54% of genitourinary cancer patients having seen a dentist in the year before cancer treatment. Notably, the high proportion of patients requiring extractions before starting BMA therapy (54% in breast cancer and 67% in genitourinary cancer) underscores the importance of proactive dental interventions. Additionally, the breast cancer cohort (median age 57) exhibited a higher prevalence of moderate to severe periodontitis (41% and 24%, respectively) compared to national averages, where periodontitis prevalence increases with age, affecting 26% of women aged 35–54 and 43.5% of those aged 55–74 [21].

In our study, 54% of breast cancer patients required dental extractions before initiating BMA therapy, with a high prevalence of periodontitis. This aligns with findings from a large prospective study of 73,737 women, which identified periodontal disease as a risk factor for breast cancer, particularly among former smokers [30]. Dental practitioners play a key role in the multidisciplinary care of cancer patients on BMAs, as pre-existing periodontal and periapical infections have been implicated as risk factors for MRONJ in 50% of MRONJ cases [15]. Additionally, poor oral health, reflected by a high decayed, filled, and missing (DMF) index, has been linked with more severe MRONJ cases [31]. Therefore, reducing the oral disease burden is essential in mitigating the future risk of MRONJ [32].

Haematopoietic stem cell transplantation (HSCT)

HSCT is a curative option for various haematological malignancies, immune deficiencies and some solid tumours [33]. However, patients undergoing HSCT face multiple treatment-related adverse effects, including an elevated risk of oral infections due to prolonged immunosuppression during the transplantation process [34].

Interestingly, patients in our study cohort with haematological malignancies had relatively better baseline oral health compared with other tumour streams. Around 45% of haematology patients were found to have good oral health, a higher proportion which is higher than in HNC (29%) and the "other" tumour stream (18%). Additionally, 43% of haematology patients were classified as having moderate oral health, which was lower than in the HNC group (48%) but comparable to other streams. Only 11% of haematology

Table 3 Management strategies and dental implications for cancer treatment

Side effect A = Acute L = Late B = Both	Management strategies	Dental implication
Head and neck RT		
Mucositis (A)	Anaesthetic mouthwash Bicarbonate/saline mouthwash *Oral hygiene Bland, soft diet Systemic pain medication	Local/systemic infection risk Compromised oral hygiene Mucosal scarring
Candidosis (A)	Oral antifungal agents Bicarbonate/saline mouthwash	Oral mucosal pain Compromised immunity
Trismus and muscle fibrosis (B)	Mouth stretching exercises Muscle massage	Restricted oral access Compromised oral hygiene Increased caries risk Pain/temporomandibular disorder/restricted function Reduced oral intake- > nutritional compromise
Taste disturbance (dysguesia) (B)	Increase variety of foods Maintain hydration	Reduced appetite Weight loss Nutritional compromise Preference for sweet foods/drinks- > Increased caries risk
Dysphagia (B)	Referral to specialist team Long-term parenteral feeding dependent	As acute side effect- > nutritional compromise and interruptions in cancer treatment Dental irrigation- > choking risk
Lymphoedema (B)	Refer to specialist team	Limited head/neck mobility Swelling around the head/neck/oral cavity
Xerostomia (L)	Avoid caffeine/tobacco Increase hydration Avoid dry foods Visualisation techniques Oral lubricants/saliva substitutes Oils (coconut, olive, natural vegetable oils) to lubricate mucosa Oral hygiene* Stimulation of saliva via sugarless gum or mints Regular dental examination essential Regular counselling about reduction of modifiable risks Counselling	Compromised function Reduced oral clearance- > stagnation food/plaque Modified oral microflora favouring cariogenic bacteria Risk for candida overgrowth Patients might favour acidic or carbonated drinks Increased caries risk Restoration of dentition is complex/challenging Quality of life impact
Radiation caries (L)	Preventive strategies (same as xerostomia) Dietary counselling Early intervention and restoration with adhesive materials if indicated Oral hygiene* Bicarbonate/saline mouthwash Consider medicament/fluoride tray when severe hypofunction	Regular dental examination Reinforce oral hygiene* Dietary counselling Restoration is challenging, disease progression is rapid

Table 3 (continued)

Side effect A = Acute L = Late B = Both	Management strategies	Dental implication
Cancer recurrence or metastasis (L)	Suspicious lesion- > refer to specialist	Regular surveillance of oral mucosa and surrounding structures is essential for early detection of cancer recurrence
Osteoradionecrosis (ORN) (L)	Optimal oral hygiene* Remove source of trauma if identified Counselling about other modifiable risks (tobacco and alcohol consumption, refined sugar consumption) Referral to specialist	Good treatment planning and removal of teeth with a poor prognosis before the start of radiotherapy Regular dental examination including soft tissue Ensuring removable dentures are well-fitted and not irritating the mucosa Exposed bone- > soft tissue trauma- palpate all mucosal surfaces during examination Avoid invasive dental procedures (extractions, dentoalveolar surgery, placement of implants)-*refer to specialist if invasive procedures indicated*
Anti-resorptive/bone-modifying/anti-angiogenic medications		
Medication-related osteonecrosis of the jaw (MRONJ) (L)	Optimal oral hygiene* Remove source of trauma Counselling about modifiable risks Early referral for specialist management is warranted	Same as ORN above Prompt management of dental infection Prompt management of soft tissue trauma Avoid invasive dental procedures-*refer to specialist if invasive procedures indicated*
Haematopoietic stem cell transplantation		
Mucositis (A)	Ice chips may be useful for some conditioning regimens (e.g. high-dose melphalan) Mucosal protectants may be helpful Elimination of infection prior to HSCT is critical Patient-controlled pump for on-demand intravenous morphine infusion may be used Otherwise as outlined within head & neck RT	Severe mucositis can lead to de-escalation or disruption of planned regimen and increased length of hospitalisation Impact on quality of life, oral function, pain Act as a portal of entry for organisms Risk of infection from mucosal injury and neutropenia Otherwise as outlined within head & neck RT
Immunocompromise (B)	Specific management strategies when infectious agent identified Prevent exposure by appropriate hand hygiene and infection control procedures by healthcare workers Empirical prophylaxis for bacterial, viral, and fungal disease HSCT recipient vaccinations due to decline in antibody titres following HSCT (1) Screening of selected donor for transmissible infections	Raised risk or localised and systemic infections: bacterial, fungal and viral Neutropenic fever (pre-engraftment) often bacterial cause Bleeding and infection risk with dental procedures Reactivation of latent viruses especially herpesviruses (cytomegalovirus and herpes simplex virus)
Salivary oral GVHD (L)	See xerostomia	See xerostomia

Table 3 (continued)

Side effect A = Acute L = Late B = Both	Management strategies	Dental implication
Mucosal oral GVHD (L)	Smooth over sharp/rough teeth Softer diet is likely better tolerated Avoid flavours which irritate oral mucosa Sodium-lauryl-sulphate free toothpaste likely better tolerated when toothpaste stings Topical corticosteroid preparations for mucosal pain Topical antifungal agents concurrently prescribed to prevent candida overgrowth	Mucosal pain and sensitivity Intolerance to acidic and spiced flavours or dry/rough textures Possible steroid-associated candida overgrowth Reduced quality of life, compromised oral function Raised risk for secondary solid malignancies especially oral squamous cell carcinoma Oral mucosal screening essential at every dental visit Low threshold for biopsy if lesion suspected
Malignancy	Refer to specialist for mucosal surveillance Life-long mucosal surveillance Low threshold for biopsy for suspicious mucosal lesions	Referral to oral medicine specialist may be warranted Biopsy suspicious lesion

*Recommended Oral Hygiene Regime: toothbrushing twice daily, use of interdental cleaning, prescription strength toothpaste (5000 ppm fluoride), apply remineralising agents such as CPP-ACP (casein-phosphopeptide-amorphous calcium phosphate), regular dental examination

[1] Dykewicz CA, Jaffe HW, Kaplan JE. Guidelines for preventing opportunistic infections among hematopoietic stem cell transplant recipients; recommendations of CDC, the Infectious Disease Society of America, and the American Society of Blood and Marrow Transplantation. 2000

patients presented with poor oral health, making it one of the lowest percentages compared to other groups such as HNC (23%) and breast (27%). Despite these relatively positive findings, there was no comparison to healthy controls, which limits the generalisability of these findings. In contrast, a study by Uutela et al. [35] compared HSCT patients with healthy controls and found poorer oral health indicators, including lower stimulated salivary flow rates and a higher incidence of dental caries.

Oral health complications are common in both pre- and post-transplant periods. A prospective study analysing oral health in patients scheduled for HSCT found that 30.9% presented with oral mucosal lesions and 17.4% required acute dental management prior to transplantation [36]. Furthermore, post-HSCT challenges are significant, with Arduino et al. [37] reporting that 59% of patients post-HSCT were affected by chronic graft-versus-host disease (cGvHD), resulting in significantly worse dental and periodontal health compared to controls ($p=0.003$ and $p=0.008$, respectively). In a study of paediatric HSCT patients, Doss et al. [38] observed a progressive worsening of oral health parameters, including plaque accumulation and gingivitis, in the first 28 days post-HSCT. These findings highlight the need for ongoing monitoring and early interventions to prevent further deterioration.

The prevalence of moderate to severe periodontitis in haematology patients was 47%, significantly lower than in HNC (64%), breast cancer (65%), and genitourinary cancers (63%) ($\chi^2=34.24$, $p<0.0001$). This variation may be attributed to more frequent dental visits with 57% of haematology patients attending a dental clinic in the previous 12 months, which was higher than in HNC (47%) and breast cancer (40%) patients. However, despite this, 26% of patients undergoing pre-HSCT dental assessment were found to have inadequate dentition, which is still markedly higher than the Australian and Victorian averages (10% and 10.3%, respectively) [21].

Pre-HSCT dental extractions are important in minimising infection risk during the period of immunosuppression. In our study, 38% of patients required pre-HSCT extractions to remove hopeless teeth. Similarly, a study by Hansen et al. [39] reported 41.4% of HSCT patients were classified as moderate to high risk for odontogenic infections, with 32.6% requiring dental treatment beforehand. Despite these interventions, a small proportion (0.57%) still experienced odontogenic complications during transplantation.

Better baseline oral health observed in haematology patients compared to other tumour streams is an encouraging finding. The position paper by the Multinational Association of Supportive Care in Cancer (MASCC) and the European Society for Blood and Marrow Transplantation (EBMT) makes recommendations for pre-HSCT patients. This involves systematic oral care, including preventative strategies to

reduce infection risk, pain management and maintaining oral function throughout the HSCT process [40].

Overall, the findings across three patient groups underscore the importance of integrating early and ongoing dental assessments and interventions into the oncology care pathway to address the complex oral health needs of these vulnerable patient groups. The implications of cancer treatment in the provision of dental care with key recommendations are summarised in Table 3.

There are a few limitations of this study. Firstly, it is retrospective and relies on existing data, which may be incomplete or biased. The reliance on patients' self-reported dental history, particularly regarding prior attendance, as well as smoking status, may have introduced recall bias. Categorising alcohol consumption as "yes/no" rather than quantitatively limits the utility of this statistic as the amount and frequency of alcohol consumption are directly related to its impact on health outcomes. The study also did not explore reasons for delayed or missed dental visits before cancer treatment, nor did it evaluate socioeconomic factors influencing patients' access to dental care. Furthermore, while this study demonstrated a high need for dental extractions, it did not evaluate the long-term oral health outcomes post-extractions or how these interventions influenced cancer treatment outcomes. With regard to measurement outcome bias, this was minimised by ensuring all researchers with responsibility for data entry were proficient with searching the EMR for accurate information.

Future research should aim to explore the impact of pre-treatment dental interventions on long-term cancer outcomes in a prospective, multicentre design to better understand how improving oral health prior to cancer treatment can influence both oral and systemic health outcomes.

Conclusion

This study emphasises the need for integrated dental and oncology care where modifiable risk factors and socioeconomic constraints intersect to impact oral health and cancer treatment outcomes. The findings reinforce the critical role of optimising oral health before, during and after cancer treatment to mitigate the risks of oral infections and complications. The dental team plays an integral role in supporting cancer patients to improve function, aesthetics and quality of life; treatment must be carefully considered and always in collaboration with the medical team. Given the barriers to accessing dental care, particularly among socioeconomically disadvantaged oncology patients, efforts should be made to expand dental services for this high-needs group.

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Declarations

Competing interests The authors declare no competing interests.

References

1. Epstein JB, Parker IR, Epstein MS, Gupta A, Kutis S, Witkowski DM (2007) A survey of National Cancer Institute-designated comprehensive cancer centers' oral health supportive care practices and resources in the USA. Support Care Cancer 15(4):357–362. https://doi.org/10.1007/s00520-006-0175-6
2. Epstein JB, Thariat J, Bensadoun RJ, Barasch A, Murphy BA, Kolnick L et al (2012) Oral complications of cancer and cancer therapy: from cancer treatment to survivorship. CA Cancer J Clin 62(6):400–422. https://doi.org/10.3322/caac.21157
3. Scully C, Epstein JB (1996) Oral health care for the cancer patient. Eur J Cancer B Oral Oncol 32(5):281–292. https://doi.org/10.1016/0964-1955(96)00005-3
4. Sathasivam HP, Davies GR, Boyd NM (2018) Predictive factors for osteoradionecrosis of the jaws: a retrospective study. Head Neck 40(1):46–54. https://doi.org/10.1002/hed.24974
5. Doerr TD, Marunick MT (1997) Timing of edentulation and extraction in the management of oral cavity and oropharyngeal malignancies. Head Neck 19(5):426–430. https://doi.org/10.1002/(SICI)1097-0347(199709)19:5%3c426::AID-HED12%3e3.0.CO;2-X
6. Moon DH, Moon SH, Wang K, Weissler MC, Hackman TG, Zanation AM et al (2017) Incidence of, and risk factors for, mandibular osteoradionecrosis in patients with oral cavity and oropharynx cancers. Oral Oncol 72:98–103. https://doi.org/10.1016/j.oraloncology.2017.07.008
7. Joshi VK (2010) Dental treatment planning and management for the mouth cancer patient. Oral Oncol 46(6):475–479. https://doi.org/10.1016/j.oraloncology.2010.03.012

8. EviQ (2018) Health professional dental considerations for patients undergoing treatment for head and neck cancer: Cancer Institute NSW [updated 25th May 2018; cited 23 August 2021]. Available from: https://www.eviq.org.au/clinical-resources/side-effect-and-toxicity-management/oropharyngeal/585-dental-considerations-for-patients-undergoing#
9. de Souza TE, Centurion BS, Ferreira LHC, de Souza AP, Damante JH, Rubira-Bullen IRF (2011) Oral adverse effects of head and neck radiotherapy: literature review and suggestion of a clinical oral care guideline for irradiated patients. J Appl Oral Sci 19(5):448–454. https://doi.org/10.1590/S1678-77572011000500002
10. Sroussi HY, Epstein JB, Bensadoun RJ, Saunders DP, Lalla RV, Migliorati CA et al (2017) Common oral complications of head and neck cancer radiation therapy: mucositis, infections, saliva change, fibrosis, sensory dysfunctions, dental caries, periodontal disease, and osteoradionecrosis. Cancer Med 6(12):2918–2931. https://doi.org/10.1002/cam4.1221
11. Kielbassa AM, Hinkelbein W, Hellwig E, Meyer-Luckel H (2006) Radiation-related damage to dentition. Lancet Oncol 7(4):326–335. https://doi.org/10.1016/S1470-2045(06)70660-1
12. Beech NM, Porceddu S, Batstone MD (2017) Radiotherapy-associated dental extractions and osteoradionecrosis. Head Neck 39(1):128–132. https://doi.org/10.1002/hed.24533
13. Koga DH, Salvajoli JV, Alves FA (2008) Dental extractions and radiotherapy in head and neck oncology: review of the literature. Oral Dis 14(1):40–44. https://doi.org/10.1111/j.1601-0825.2007.01453.x
14. Yarom N, Shapiro CL, Peterson DE, Poznak CHV, Bohlke K, Ruggiero SL et al (2019) Medication-related osteonecrosis of the jaw: MASCC/ISOO/ASCO Clinical Practice Guideline. J Clin Oncol 37(25):2270–2290. https://doi.org/10.1200/JCO.19.01186
15. Ruggiero SL, Dodson TB, Fantasia J, Goodday R, Aghaloo T, Mehrotra B et al (2014) American Association of Oral and Maxillofacial Surgeons position paper on medication-related osteonecrosis of the jaw—2014 update. J Oral Maxillofac Surg 72(10):1938–1956. https://doi.org/10.1016/j.joms.2014.04.031
16. Poulopoulos A, Papadopoulos P, Andreadis D (2017) Chemotherapy: oral side effects and dental interventions. A review of the literature. Stomatol Dis Sci. https://doi.org/10.15761/SDS.1000156
17. Barker B, Barker G (2001) Oral management of the patient with cancer in the head and neck region. J Calif Dent Assoc 29(8):619–623. https://doi.org/10.1234/jcda-2001
18. National Study of Adult Oral Health (2017–18) Australia's oral health: national study of adult oral health 2017–18. Australian Institute of Health and Welfare. AIHW, Canberra. https://doi.org/10.1111/adj.12758
19. Silness J, Löe H (1964) Periodontal disease in pregnancy II. Correlation between oral hygiene and periodontal condition. Acta Odonatol Scand 22(1):121–135. https://doi.org/10.3109/00016356408993968
20. Tonetti MS, Greenwell H, Kornman KS (2018) Staging and grading of periodontitis: framework and proposal of a new classification and case definition. J Periodontol 89(Suppl 1):S159–S172. https://doi.org/10.1002/JPER.18-0001
21. Australian Institute of Health and Welfare (2020) Oral health and dental care in Australia. [updated 23 March 2021; cited 23 August 2021]. Available from: https://www.aihw.gov.au/reports/dental-oral-health/oral-health-and-dental-care-in-australia/contents/introduction
22. Brennan MT, Treister NS, Sollecito TP, Schmidt BL, Patton LL, Lin A, Elting LS, Helgeson ES, Lalla RV (2023) Dental caries postradiotherapy in head and neck cancer. JDR Clin Transl Res 8(3):234–243. https://doi.org/10.1177/23800844221149823
23. Devi S, Singh N (2014) Dental care during and after radiotherapy in head and neck cancer. Natl J Maxillofac Surg 5(2):117–120. https://doi.org/10.4103/0975-5950.154828
24. Rupe C, Basco A, Schiavelli A, Cassano A, Micciche' F, Galli J, Cordaro M, Lajolo C (2022) Oral health status in patients with head and neck cancer before radiotherapy: baseline description of an observational prospective study. Cancers (Basel) 14(6):1411. https://doi.org/10.3390/cancers14061411
25. Sahingur SE, Yeudall WA (2015) Chemokine function in periodontal disease and oral cavity cancer. Front Immunol 6:214. https://doi.org/10.3389/fimmu.2015.00214
26. Kovarik JP, Voborna I, Barclay S, Nicol A, Kelly C, Kovarik PD, Iqbal MS, Kovarik J (2021) Dental loss after radiotherapy for head and neck cancer. Br Dent J 231(8):473–478. https://doi.org/10.1038/s41415-021-3536-4
27. Patel V, Mansi J, Ghosh S, Kwok J, Burke M, Reilly D et al (2018) MRONJ risk of adjuvant bisphosphonates in early-stage breast cancer. Br Dent J 224(2):74. https://doi.org/10.1038/sj.bdj.2018.63
28. Gomes-Silva W, Morais-Faria K, Rivera C, Najas GF, Marta GN, Vasconcelos KGMdC, Carvalho HdA, de Castro G Jr, Epstein JB, Santos-Silva AR (2021) Impact of radiation on tooth loss in patients with head and neck cancer: a retrospective dosimetric-based study. Oral Surg Oral Med Oral Pathol Oral Radiol 132(4):409–417. https://doi.org/10.1016/j.oooo.2021.06.021
29. Sohn HO, Park EY, Jung YS, Lee JY, Kim EK (2021) Effects of the professional oral care management program on patients with head and neck cancer after radiotherapy: a 12-month follow-up. J Dent Sci 16(1):453–459. https://doi.org/10.1016/j.jds.2020.06.008
30. Freudenheim JL, Genco RJ, LaMonte MJ, Millen AE, Hovey KM, Mai X et al (2016) Periodontal disease and breast cancer: prospective cohort study of postmenopausal women. Cancer Epidemiol Biomarkers Prev 25(1):43–50. https://doi.org/10.1158/1055-9965.EPI-15-0875
31. Caldas RJ, Antunes HS, Pegoraro CdOR, Guedes FR, da Silva Santos PS (2021) Oral health condition in cancer patients under bisphosphonate therapy. Support Care Cancer. https://doi.org/10.1007/s00520-021-06410-7
32. Oral and Dental Expert Group (2019) Therapeutic guidelines: oral and dental, 3rd edn. Therapeutic Guidelines Limited, Melbourne
33. Australasian Bone Marrow Transplant Recipient Registry (ABMTRR) (2021) [cited 5 September 2021]. Available from: https://www.abmtrr.org/
34. Ogonek J, Kralj Juric M, Ghimire S, Varanasi PR, Holler E, Greinix H et al (2016) Immune reconstitution after allogeneic hematopoietic stem cell transplantation. Front Immunol 7:507. https://doi.org/10.3389/fimmu.2016.00507
35. Uutela P, Passweg J, Halter J, Weiger R, Waltimo T, Mauramo M (2019) Common oral diseases in allogeneic haematopoietic stem cell transplantation (HSCT) recipients pre-HSCT. Eur J Haematol 102(4):351–356. https://doi.org/10.1111/ejh.13209
36. Skallsjö K, von Bültzingslöwen I, Hasséus B, Johansson JE, Öhman J, Raber-Durlacher JE, Huysmans MC, Laheij AM, van Leeuwen SJ, Hovan AJ, Garming Legert K (2023) Oral health in patients scheduled for hematopoietic stem cell transplantation in the Orastem study. PLoS ONE 18(5):e0285615. https://doi.org/10.1371/journal.pone.0285615
37. Arduino PG, Gambino A, Giaccone L, Suria M, Carbone M, Carrozzo M, Broccoletti R, Conrotto D (2022) Oral health status after hematopoietic stem cell transplantations: outcomes from an adult Italian population. Spec Care Dentist 42(6):585–591. https://doi.org/10.1111/scd.12729
38. Doss LM, Dandoy CE, Kramer K, Pate A, Flesch L, El-Bietar J, Lane A, Davies SM, Thikkurissy S (2018) Oral health and hematopoietic stem cell transplantation: a longitudinal evaluation of the first 28 days. Pediatr Blood Cancer 65(1):e26773. https://doi.org/10.1002/pbc.26773
39. Hansen HJ, Estilo C, Owosho A, Solano AK, Randazzo J, Huryn J, Yom SK (2021) Dental status and risk of odontogenic complication in patients undergoing hematopoietic stem cell transplant.

Support Care Cancer 29:2231–2238. https://doi.org/10.1007/s00520-020-05733-1

40. Elad S, Raber-Durlacher JE, Brennan MT, Saunders DP, Mank AP, Zadik Y, Quinn B, Epstein JB, Blijlevens NM, Waltimo T, Passweg JR (2015) Basic oral care for hematology–oncology patients and hematopoietic stem cell transplantation recipients: a position paper from the joint task force of the Multinational Association of Supportive Care in Cancer/International Society of Oral Oncology (MASCC/ISOO) and the European Society for Blood and Marrow Transplantation (EBMT). Support Care Cancer 23:223–236. https://doi.org/10.1007/s00520-014-2378-x