Oral Health Status in Jordanian Children with Cancer Undergoing Chemotherapy

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Abstract

Aim: To assess the oral health status in Jordanian pediatric oncology patients undergoing chemotherapy. Methods: 100 children with cancer undergoing chemotherapy (37 females and 63 males) and age and sex-matched 100 healthy children were examined. Dental caries, plaque, gingival health, soft tissue lesions, dental developmental defects and dental treatment need urgency were assessed. Statistically significant results were determined if P was less than 5%. Results: Pediatric patients suffering from cancer had statistically significant higher caries in the primary dentition (dmft, dmfs) (P=0.002, P=0.001 respectively), but not in the permanent dentition (DMFT, DMFS) (P=0.361, P=0.281 respectively). No differences were detected in the plaque deposits (P=0.378). Fifteen percent of the study group had healthy gingiva compared to 32% in the control group. The difference was statistically significant (P=0.006). Twenty percent of the oncology patients had soft tissue problems (6 had mucositis and 14 had aphthous ulceration) (P=0.000). Sixteen patients had hypoplastic teeth among the oncology group, while only two children in the healthy group had such defect (P=0.001). Dental treatment need urgency was not statistically significant between the two groups (P=0.219). Conclusions: Compared to healthy children, pediatric patients with cancer and undergoing chemotherapy had higher caries incidence in the primary dentition, but not in the permanent dentition, higher gingivitis index in the upper jaw, higher prevalence of soft tissue lesions including aphthous ulceration and mucositis, as well as higher prevalence of hypoplasia. However, plaque deposits were not statistically significant between the two groups.

Key Words: Chemotherapy, Children, Cancer, Oral health status, Caries, Treatment needs

Introduction

Although malignancies are rare in children and make up less than 1% of all cancers diagnosed, they represent the second most common cause of death in childhood [1,2]. Leukemias and lymphomas constitute approximately 40% of pediatric neoplastic diseases, while solid tumors make up the remaining percentages [3]. Leukemia is the most common hematological tumor in children [2].

In Jordan, leukemia also is the most common childhood malignancy [4]. The incidence has been (32.2% for females and 28.1% for males) among childhood cancers, followed by brain and central nervous system tumors (18.8% for males and females), and lymphomas (16.2%) [4].

Today, more than 80% of children diagnosed with cancer are alive 5 years after diagnosis due to the advances in childhood cancer therapy [5]. Direct treatment of malignancies involves chemotherapy, radiotherapy and bone marrow transplantation [6].

Oral complications of cancer or cancer treatment can be painful and lead to severe discomfort, which interferes with proper nutrition and may dramatically affect treatment compliance. Cytotoxic treatment can cause a breach in the mucosal integrity, allowing pathogenic organisms to spread systemically, and could result in spread of serious infections from the oral cavity to the body [7]. Complications may include mucositis, nausea and vomiting, bone marrow suppression, alopecia, infections, bleeding, and xerostomia in cases treated with chemotherapy [7,8]. Radiotherapy has been associated with xerostomia, hypovascularity, osteoradionecrosis, mucositis, trismus and radiation caries, as well as developmental dental and maxillofacial abnormalities in pediatric patients [9]. Most of these complications frequently occur in the oral cavity and appear to be far more common in younger children [10].

The most frequently documented source of sepsis in the immunosuppressed cancer patient is the mouth; therefore, early and definitive dental intervention, including comprehensive oral hygiene measures, reduces the risk for oral and associated systemic complications [11,12]. Although many reports have explored the links between cancer and oral and dental diseases [13-21], comprehensive reports concerning the various oral problems in the same group of pediatric patients with cancer are uncommon.

Children diagnosed with cancer have been found to have a higher prevalence of dental caries [14-17,19,21]. The same trend of higher plaque indices was also reported in other literature [17,18,20].

Gingivitis has been reported in a higher percentage of cancer patients. The study by Uderzo et al. reported serious gingivitis in 59.2% and periodontal involvement in 3.7% of cancer cases [17]. A higher percentage of gingivitis (89%) was reported among a Turkish cancer pediatric population [19]. The oral soft tissue problems most frequently reported in cancer patients were mucositis, fungal or candidal infections, gingival bleeding, herpetic lesions, and apthous ulcerations [19,22,23]. Hypodontia, microdontia, abnormal crown root ratios are examples of developmental defects documented in literature inflicted by cancer therapy [13,17,18,23]. However, no significant differences in plaque index or tooth brushing frequency between oncology and healthy children were reported [14].

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Considering these facts and the sparse comprehensive reports about oral health in patients with cancer, it seemed appropriate to conduct a study designed to investigate the incidence and nature of oral problems occurring in a population of Jordanian pediatric cancer patients.

The aims of this observational cross-sectional study were to investigate the oral health conditions of a group of children and adolescents diagnosed with cancer, and assess whether patients' oral conditions are associated with cancer and cancer therapy complications and to compare the findings to findings in healthy children. Our working hypothesis was that oral health status of children with cancer undergoing chemotherapy is similar to the oral health status of healthy children.

Methods

Study sample

A total of 100 children with confirmed malignancies were examined. The study group consisted of patients attending two tertiary care hospitals in Jordan (King Abdullah University Hospital and King Hussein Medical City). All of the patients were between 2 and 17 years of age, had been diagnosed with cancer, and were currently undergoing chemotherapy at either the induction or maintenance phases.

A control group of 100 healthy school children was obtained to match the cancer children with respect to age and sex. The control children were randomly selected from 600 children attending a private school in Amman whose principal cooperated with the research team and the parents of the children consented to the dental examination after they were provided with a detailed letter about the purpose of the screening.

The oral examination was carried out under identical circumstances. None of the children (control group and study group) had special dental prophylactic treatment (for example, fluoride applications, professional tooth cleaning, and oral hygiene instructions) before examination, or took any medication at the time of examination. Before their cancer treatment, the children of the study group received no special dental care.

Information regarding the name, medical history of each child, in addition to the age according to the date of birth, was taken from the child hospital medical record for the study group and from the child school medical record for the control group. After obtaining approval of the Institutional Review Board at Jordan University of Science and Technology, assent from the children and consent from their parents were obtained after explaining the purpose of the study prior to the start of the survey.

The examining team consisted of a single examiner and a recorder. Examiner calibration with an experienced clinical examiner was conducted to establish diagnostic consistency before the study was begun. The investigator was trained in several calibration exercises, including soft tissue assessment, caries diagnosis, plaque deposits, gingival health and tooth developmental defects. A pilot study was carried out on 20 children (10 with cancer and 10 who were healthy). In order to test intra-examiner reproducibility for caries and tooth developmental defects, the children from the pilot study were re-examined three weeks after the initial screening.

Each child was examined under natural day light; the subject was positioned to receive maximum illumination, while avoiding discomfort from direct sunlight on either the subject or the examiner. The chair was facing a window through which the light entered, as close to the light as possible. A plain mirror and a blunt periodontal probe were used. Diagnostic criteria depended on visual evidence of a lesion, with a blunt CPI periodontal probe being used only to remove plaque. Intraorally, a full charting of teeth present was made. Caries were recorded according to the criteria suggested by the World Health Organization [24,25].

A systematic approach of the examination for dental caries was followed, starting from the last upper right molar and proceeding in an orderly manner from one tooth or tooth space to the adjacent tooth or tooth space, reaching the upper left last molar, then going to the lower left last molar and passing to the lower right last molar. An alphabetical coding system was used for recording the status of the primary teeth, while a numerical coding system was used for the permanent teeth [26].

For plaque and gingival scores, the mouth was divided into six parts (i.e., sextants), with each jaw having three sextants namely right, left (distal surface of the canine to the distal surface of the most posterior tooth present for either side) and middle (mesial surface the right canine to the surface of the left canine). Each tooth unit was given an individual score for the parameter being measured, and the highest score was recorded for each jaw. Plaque was scored using the criteria described by Todd and Dodd as: no deposits (0), small amounts of recent deposits (1), or abundant amounts of long-standing deposits (2) [27]. The highest score was given to the whole arch and for data analysis, the highest of the two arches was given for the patient. Gingival condition was assessed using the gingival index criteria described by Loe and Silness in the early 1960s. It was recorded as follows: Normal gingival (0); mild inflammation: slight change in color, slight edema, no bleeding on probing (1); moderate inflammation: redness, edema, and glazing. Bleeding on Probing (2); and severe inflammation: marked redness and edema. Tendency to spontaneous bleeding (3) [28].

Tooth developmental defects were recorded as "present" or "absent with" assigning the teeth involved. Hypoplastic teeth, that is, teeth with white patches, coloured flecks, or horizontal lines, were noted.

After asking if the child was suffering any oral discomfort, a thorough, systematic examination of the oral and perioral tissues was performed. Extraorally, submental, submandibular, anterior and posterior cervical, and pre- and postauricular lymph nodes were palpated to detect enlargement and/or tenderness. The perioral skin and the lips also were examined. Buccal and sulcular mucosa, the tongue, the floor of the mouth, the hard and soft palates, and the fauces were examined systematically for evidence of any abnormality.

The following criteria were applied in determining the presence of specific soft tissue abnormalities as described by

Fayle and Curzon [22]: Ulceration (a pathological breech in the continuity of the oral mucosa with exposure of underlying tissues); mucositis (inflammation of the oral mucosa, characterized by reddening and pain); lip cracking (painful dryness and cracking of lips); and lymphadenopathy (enlargement and or tenderness elicited on palpation of two or more nodes in any of the lymph nodes listed above).

The dental treatment urgency for each child was assessed according to codes developed by the Association of State and Territorial Dental Directors scale as follows: No obvious need for dental treatment (0); Need for non-urgent dental treatment (e.g. small lesions or inflamed gingiva) (1); Need for early dental care due to obvious frank caries but neither pain nor infection is present (2); and Need for immediate dental care due to pain or infection or soft tissue ulceration of more than two weeks duration (3) [29].

Data analysis

The data were entered into the Statistical Package for the Social Sciences, version 19.0 (SPSS® Inc., Chicago, Illinois, USA) and analyzed to determine the various frequencies of the different parameters of oral health. Dental caries was analyzed after grouping the children into four age groups: 2-5 years, 6-9 years, 10-13 years, and 14-17 years using Student's t-test. The Mann-Whitney U test was used for analyses of gingival health, plaque deposits, soft tissue status, and treatment urgency need. Analysis of the association of the treatment phase and the various parameters was carried out using the chi-square test. Probability levels of fewer than 5% were considered significant for all of the analyses.

Results

A total of 100 oncology children (37 females and 63 males), and age and sex-matched 100 control children, were assessed. *Table 1* shows the age and sex distribution of the study and control groups. The age range for children was 2-17 years (mean age = 8.27 ± 3.71 SD).

Table 1. Age and gender distribution of the study (Cancer group) and healthy Jordanian children (control group).

Age Group (years)	Cancer group		Control group	
	Female	Male	Female	Male
2-5	11	14	11	14
6-9	13	27	13	27
10-13	8	17	8	17
14-17	5	5	5	5
Total	37	63	37	63
	100	100		

Calibration showed a high level of agreement between trainer and investigator for caries diagnosis, plaque deposits, gingival condition, and tooth developmental defects with respective kappa scores of 0.88, 0.90, 0.89, and 0.92.

Table 2. Dental caries in primary and permanent teeth in a group of Jordanian children with cancer compared with a control group.

Age (years)	Cancer group			Control Group	
		Sex	Mean (± SD)	Mean (± SD)	p-value
2-5	dmft	F	3.45 (2.25)	2.00 (2.05)	0.045
		M	4.50 (5.35)	2.14 (2.35)	
		T	4.04 (4.23)	2.08 (2.18)	
	dmfs	F	3.91 (2.59)	2.27 (2.41)	0.059
		M	7.86 (12.06)	2.5 (2.82)	
		T	6.12 (9.25)	2.4 (2.60)	
6-9	Dmft	F	3.92 (2.84)	2.00 (2.04)	0
		M	5.56 (3.23)	2.04 (2.33)	
		T	5.03 (3.17)	2.03 (2.21)	
	dmfs	F	5.62 (4.81)	2.00 (2.04)	0
		M	7.81 (5.47)	2.15 (2.43)	
		T	7.10 (5.31)	2.10 (2.29)	
	DMFT	F	0.85 (1.52)	1.15 (1.41)	0.265
		M	1.33 (1.60)	1.81 (1.97)	
		T	1.18 (1.57)	1.6 (1.81)	
	DMFS	F	0.92 (1.71)	1.23 (1.49)	0.617
		M	1.78 (2.58)	2.00 (2.34)	
		T	1.50 (3.72)	1.75 (2.11)	
10-13	dmft	F	1.13 (1.55)	2.00 (2.33)	0.008
		M	1.29 (1.72)	3.24 (2.41)	
		T	1.24 (1.64)	2.84 (2.41)	
	dmfs	F	1. 50 (2.27)	2.63 (3.07)	0.021
		M	1.41 (1.84)	4.12 (2.74)	
		T	1.44 (1.94)	3.64 (2.87)	
	DMFT	F	3.50 (3.47)	2.38 (1.60)	0.021
		M	4.12 (2.32)	2.50 (1.38)	
		T	3.92 (2.68)	2.48 (1.42)	
	DMFS	F	4.25 (3.92)	3.00 (1.93)	0.032
		M	5.00 (3.73)	2.94 (1.60)	
		T	4.76 (3.72)	2.96 (1.67)	
14-17	DMFT	F	6.60 (4.98)	5.80 (1.30)	0.346
		M	6.00 (3.40)	4.20 (0.84)	
		T	6.30 (4.03)	5.00 (1.33)	
	DMFS	F	6.60 (4.98)	6.60 (1.67)	0.492
		M	6.60 (3.85)	4.60 (0.89)	
		T	6.60 (4.19)	5.60 (1.65)	

Intraexaminer reproducibility was tested at the beginning of the study by re-examining 20 patients from the pilot study and retesting them 3 weeks later. There was no difference in the assessment of caries, gingival condition or hypoplasia. The

kappa scores for caries, gingivitis and hypoplasia were 0.84, 0.88 and 0.85 respectively.

Dental Caries

The prevalence of dental caries for the different age groups is listed in *Table 2*. As dmft, dmfs, DMFT and DMFS are affected by age, the children were divided into 4 groups according to their age.

In the age group 2-5 years old, the caries scores of the study group were significantly higher than in the control group with regards to dmft (P= 0.045) but not to dmfs (P= 0.059).

In the age group 6-9 years old, the caries scores of the study group were significantly higher than in the control group with regards to dmft (P=0.000) and dmfs (P=0.000) but not to permanent teeth with regards to either DMFT (P=0.265) or DMFS (P=0.617).

In the age group 10-13 years, the caries scores of the study group were significantly higher than in the control group with regards to DMFT (P=0.021) and DMFS (P=0.032). The same scores were not statistically significant in the higher age group (14-17 years) with regards to either DMFT (P=0.346) or DMFS (P=0.492).

Plaque Deposits

The mean plaque index for the cancer group was (1.30 ± 0.745), while the mean plaque index for the control group was (1.39 ± 0.723). There were no statistically significant differences found between the two groups with regard to the plaque deposits (P=0.378). Only 15.5% of the sample had no plaque deposits at all (score 0), with a slightly higher proportion (54.8%) from the healthy group (*Table 3*).

Table 3*. Dental plaque deposits, gingivitis, soft tissue lesions, hypoplasia, and treatment urgency in a group of Jordanian children with cancer compared with a control group.*

	Control group	**Cancer group**	**Total**	**P-value**
	N (%)	**N (%)**	**N (%)**	
Plaque Deposits				
No Deposits	17 (54.8%)	14 (45.2%)	31 (100%)	
Small Amounts of Recent Deposits	36 (52.2%)	33 (47.8%)	69 (100%)	
Abundant Amounts of Long-Lasting Deposits	47 (47%)	53 (53%)	100 (100%)	0.378
Gingivitis				
Normal gingiva	32 (68.1%)	15 (31.9%)	47 (100%)	
Mild gingivitis	54 (42.2%)	74 (57.8%)	128 (100%)	0.006
Moderate gingivitis	14 (60.9%)	9 (39.1%)	23 (100%)	
Severe gingivitis	0 (0%)	2 (100%)	2 (100%)	
Soft Tissue Lesions				
No abnormalities detected	100 (55.6%)	80 (44.4%)	180 (100%)	0
Mucositis	0 (0%)	6 (100%)	6 (100%)	
Ulceration	0 (0%)	14 (100%)	14 (100%)	
Hypoplasia				
Normal	98 (53.8%)	84 (46.2%)	182 (100%)	
Hypoplastic	2 (11.1%)	16 (88.9%)	18 (100%)	0.001
Treatment Urgency				
No obvious need for dental treatment	17 (65.4%)	9 (34.6%)	26 (100%)	
Need for non-urgent treatment	31 (48.4%)	33 (51.6%)	64 (100%)	
Need for early dental care	38 (48.1%)	41 (51.9%)	79 (100%)	
Need for immediate dental care	14 (45.2%)	17 (54.8%)	31 (100%)	0.219

Gingival Health

The mean gingival index for the cancer group was (0.98 ± 0.568), and for the control group was (0.82 ± 0.657). Significant differences between the two groups were recorded with regard to gingivitis scores (*Table 3*). Forty seven children had healthy gingiva. Among them 68.1% were from the healthy group compared to 31.9% from the study group; the difference was statistically significant (p=0.006) (*Table 3*).

Among the various stages of chemotherapy, the differences in gingival inflammation were not statistically significant (P=0.220). Mild to moderate gingivitis was reported more in the induction stage of treatment (*Table 4*).

Table 4*. Correlation between treatment phase with gingivitis and soft tissue lesions in a group of Jordanian children with cancer.*

	Treatment Severity			
Condition	**Induction/Solid**	**Maintenance**	**Total**	**P-value**
Gingivitis				
Normal gingival	6 (40%)	9 (60%)	15 (100%)	0.22
Mild gingivitis	48 (64.9%)	26 (35.1%)	74 (100%)	
Moderate gingivitis	7 (77.8%)	2 (22.2%)	9 (100%)	
Severe gingivitis	1 (50%)	1 (50%)	2 (100%)	
Total	62 (62%)	38 (38%)	100 (100%)	
Soft Tissue Lesions				
No abnormalities	53 (66.3%)	27 (33.8%)	80 (100%)	0.005
Mucositis	0 (0%)	6 (100%)	6 (100%)	

Ulceration	9 (64.3%)	5 (35.7%)	14 (100%)	
Total	62 (62%)	38 (38%)	100 (100%)	

Soft Tissue Lesions

The association between the malignancy and soft tissue lesions was the greatest. Among healthy children, there were no soft tissue lesions at all while in the cancer group, eighty patients had no problems, 6 had mucositis and 14 had aphthous ulcerations (P=0.000) (*Table 3*). There were no other soft tissue lesions reported among the study group. The soft tissue lesions were also significantly related to the treatment stage (severity) among the cancer group (P=0.005). All of the 6 children with mucositis were in the maintenance phase. Of the 14 patients who developed ulcerations, 9 of them were in the induction phase while 5 were in the maintenance phase (*Table 4*). *Table 5* shows the distribution of soft tissue lesions among the various types of cancers. The solid tumors had only ulceration as a complication. In leukemia, both ulcerations and mucositis were reported.

Table 5. Relationship between Medical Diagnosis & Soft Tissue Lesions in a Group of Jordanian Children with cancer.

Medical Diagnosis		Soft Tissue Lesions			Total
					N
		No abnormalities detected	Mucositis	Ulceration	(% of the total sample)
Acute Lymphoblastic Leukemia	Count (% within the disease)	64 (84.2%)	6 (7.9%)	6 (7.9%)	76 (76%)
Acute Myeloblastic Leukemia	Count (% within the disease)	2 (50%)	0 (0%)	2 (50%)	4 (4%)
Lymphoma	Count (% within the disease)	6 (60%)	0 (0%)	4 (40%)	10 (10%)
Medullablastoma	Count (% within the disease)	3 (100%)	0 (0%)	0 (%)	3 (3%)
Neuroma	Count (% within the disease)	2 (100%)	0 (0%)	0 (0%)	2 (2%)
Osteosarcoma	Count (% within the disease)	1 (33.3%)	0 (0%)	2 (66.7%)	3 (3%)
T-cell Leukemia	Count (% within the disease)	1 (100%)	0 (0%)	0 (0%)	1 (1%)
Wilm's Tumor	Count (% within the disease)	1 (100%)	0 (0%)	0 (0%)	1 (1%)
Total	Count (% of the total sample)	180 (90%)	6 (3%)	14 (7%)	100 (100%)

Hypoplasia

Nine percent of the total sample cases had some form of hypoplasia. Among the 18 cases with hypoplasia, 16 patients were in the cancer group, while only 2 cases were in the healthy group. The difference between the two groups was statistically significant (P=0.0001) (*Table 3*).

Dental Treatment Urgency Need

Among the group who had "No obvious need for dental treatment," 9 patients were from the cancer group while 17 children were from the healthy group. In the cancer group, there were higher percentages of children in need of immediate dental care, yet the results were not statistically significant (P=0.219) (*Table 3*).

Discussion

Dental caries

The present study was consistent with the findings of other previous literature, where similar or slightly higher prevalences of dental caries were reported for children with cancer when compared to systemically healthy children [13-17,19,21,30].

The DMFT scores for the control group were consistent with what had been reported previously in the literature regarding Jordanian children. Albashaireh et al. reported a mean DMFT of 2.51 for the 12-13 years old children [31]. In the 10-13 year old group, there were statistically significant differences between the cancer patients and healthy children (DMFT: P=0.021, DMFS: P=0.032). This may be explained by the higher prevalence of hypoplastic molars seen in the study group where such teeth are more prone to caries [17].

In the 14-17 years of age, the difference was statistically significant. This may be explained by the high standard deviation values in the study group. In the 6-9 years of age, there was no difference in the permanent teeth caries prevalence. This might be explained by the fact that newly erupted permanent teeth had not had a long enough time in the oral environment to develop caries. This was emphasized by the low value of DMFT and DMFS.

In age group 2-5 years old, our study showed a mean dmft lower than that reported by Sayegh et al. with a mean dmft of 3.1 in the 4–year-olds and 4.1 in children 5 year of age [32]. On the other hand, the results in this study were higher than that reported by Rajab and Hamdan who studied dmft in age group 1-5 years [33]. The difference between our results and the previous mentioned studies may be due to the different age groups studied in Jordan [33,34].

By comparing the two groups in our study, the significantly higher prevalence of dental caries in the cancer group may be explained by the fact that children at an early age may be overwhelmed by their medical condition and ignore their dental health. Other reasons may include the fact that at a certain stage in cancer treatment, the patient becomes more susceptible to caries due to a change to a soft diet, especially when the child develops mucositis or ulceration. Caries may also develop as a result of thick saliva detected in these children during treatment phases [34].

Plaque deposits

In agreement with the previous literature, no difference was detected between the cancer and healthy groups in relation to plaque deposits [13,14]. On the other hand, the study by Uderzo et al. reported a higher prevalence of soft plaque deposits [17]. Alpastan also reported a higher plaque index [18]. The difference in our findings and theirs may be explained by the difference in methodology, since Uderzo et al. studied cancer patients undergoing bone marrow transplant while Wellbery and Dens examined children undergoing chemotherapy alone [13,14,17]. With regards to the plaque index in healthy children, our results were consistent with what was reported (1.44 ± 0.66 SD) previously in Jordan by Taani [35].

Gingival health

The study findings agree with the vast majority of previous literature among the cancer patients [17-20]. On the other hand, Dens et al. reported a non-statistically significant difference between the two groups [14].

The higher gingivitis score may be explained in part by the altered immune response during periods of chemotherapy where the subjects become more susceptible to infection and also by the less effective oral hygiene practices among the oncology children [34]. Some parents reported that they were instructed not to brush their children's teeth during courses of treatment. Many dental and medical professionals still believe that tooth brushing increases the risk of bacteremia and bleeding [34]. Previously, some advocated the discontinuation of oral hygiene with a toothbrush [36]. Such belief is not evidence–based, where good oral care in cancer children has not been shown to increase septicemia or infections in the oral cavity [11,12,37,38].

Hypoplasia

A significantly higher number of cancer children suffered hypoplasia is in agreement with previous studies [10,13,39]. One of the limitations of our study was that we were unable to assess all kinds of developmental abnormalities. This is due to the fact that most of the developmental defects need radiographic assessment to confirm diagnosis, which was not available at the examination site. The examiner observed no congenitally missing teeth. The literature was inconsistent regarding the prevalence of hypoplasia in cancer patients.

The range of hypoplasia reported in the literature among the cancer patients ranged from 13% to 95%. The results of this study fall in the lower range and are in agreement with studies reporting the range between 13% and 17% [30,40]. On the other hand, 39% of hypoplasia was reported by Minicucci et al. [41]. Alpaslan et al. reported a higher percentage (47%) [18]. A much higher prevalence of this defect (95%) was reported among cancer children [42]. This controversy in the published data may be explained by the fact that developmental defects depend on several factors: kind of tumor studied; chemotherapy protocol; patient age; the stage of histogenesis of the teeth; concomitant use of radiotherapy; and dental assessment methodology [10].

Soft tissue lesions

The association between the malignancy and soft tissue lesions was the greatest. Oral complications from the treatment of neoplastic diseases are common and are very significant as they can account for patient discomfort and compromised food intake [25]. The incidence of oral complications has been reported to range from approximately 20% to 90% in various studies [12,23]. The wide range of soft tissue lesions among the cancer pediatric patients may in part be due to the timing of examination of the cancer patients as well as to the design of the studies. Moreover, not all patients receiving chemotherapy developed oral complications [24].

Therefore, the pediatric dentist and the dental team should be aware of the different clinical and biological characteristics of each neoplastic disease, and the various types and phases of treatment in the assessment of his patients. The clinical presentation of oral complications can be altered due to a patient's immunosuppression; therefore, lesions should be cultured to obtain an accurate diagnosis [22]. Attention to oral microbial control, meticulous personal hygiene, and palliative treatment of soft tissue lesions may significantly reduce the oral morbidity associated with cancer therapies [43].

Dental treatment need

Over 95% of cancer patients needed dental treatment in this study, which is similar to a previous study in Turkey where Dodan et al. found that 91% of his sample of leukemia children needed dental treatment [19]. This can partly be explained by long-term dental complications of oncologic therapy. Complications can include abnormal dental and craniofacial development at any point prior to maturation, such as enamel hypoplasia and variations in quantity, and complexity and quality of the oral flora during chemotherapy, which can make the teeth more susceptible to caries and periodontal diseases [18,43,44]. However, socio-economic factors such as the income and the educational status of the parents, the place of residence, nutrition, and oral hygiene motivation should also be considered. Another reason of the high prevalence of dental problems in cancer patients might be the fear of dentists to treat these patients due to the high risk of infection and bleeding. Another explanation of the high treatment needs in this study sample were the high caries prevalence and the soft tissue lesions.

The study sample was a convenience sample because of two reasons: the first was the two chosen centers used the same chemotherapeutic protocols for cancer patients and the second was because of the easy access to the cancer patients in these two centers. The convenience sample has the limitation of generalizability of this sample to the whole population of children with cancer. Consequently, the results of this study should be interpreted with caution. Future research is needed to study the group of children undergoing radiotherapy in other oncology centers in Jordan and compare the two groups together.

Conclusions

This is the first study in Jordan that examines the oral health status in a sample of cancer patients. By comparing the data of cancer patients to that of a control sample, we conclude that

the cancer samples have higher caries in the primary dentition, but not in the permanent dentition; a higher gingivitis index, but with no statistically significant plaque deposits difference; a higher prevalence of soft tissue lesions, including ulceration and mucositis; and the prevalence of hypoplasia, which was significantly higher.

As treatment protocols for pediatric cancer patients become more successful in terms of cure rate, more attention should be given to the oral health status of those patients. Dental examinations and an intense oral hygiene program before, during and after chemotherapy in these patients is needed. Patients, parents, and all health care workers involved in the treatment should be instructed about the oral problems and their prevention and management protocols. Pediatric dentists should realize that these issues are rarely discussed by the physicians and nurses involved in the patient's care. Furthermore, the participation of a pediatric dentist in the hematology/oncology team is of irrefutable importance.

Author Contributions

- 1st Author: Mentor, Idea of the Master thesis, Pediatric dentist and dental public health specialist, development of the study instruments, training of the examiner, planned statistical analysis, wrote the manuscript.
- 2nd Author: Performed all examinations for the study patients in partial fulfillment of the Master's Degree in Pediatric Dentistry, wrote the original thesis, contributed to the discussion.
- 3rd Author: Co-mentor of the Master thesis, Pediatric Oncologist, reviewed the protocol and literature review as well as contributed substantially to the discussion as well as helped recruiting the patients.
- 4th Author: Co-investigator, Pediatric Oncologist, recruited patients as an oncologist, reviewed the whole paper and the Master thesis.
- 5th Author: Pediatrician and co-investigator, recruited children for the study, reviewed all parts of the manuscript and contributed substantially to the discussion.

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