



Association between breast cancer chemotherapy, oral health and chronic dental infections: a pilot study

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Abstract

Breast cancer has developed to become the leading type of cancer in females. For this study, 80 women were examined after chemotherapy for breast cancer and compared to 80 healthy age-matched women. This cross-sectional study comprised a dental examination with number of teeth, caries frequency (DMFT) and the presence of periodontal diseases (PSI). With the help of X-rays (OPG), the number of root canal fillings and apical lesions (LEO/LPO) were recorded. Furthermore, the education level, body mass index (BMI), smoking habits and general health conditions were recorded. All women completed questionnaires on oral health-related quality of life (OHIP-G14) and general well-being (HADS-D). To assess the influence of cancer therapy on oral health parameters, appropriate generalized linear models were fitted with disease status as main explanatory variable, adjusting for age and education. For OHIP and HADS, we additionally adjusted for number of missing teeth. The examined 160 women showed a comparable mean age (60.4 years) and an average BMI of 24.6. Cancer patients showed a higher risk for missing teeth ($p < 0.001$) and more apical lesions ($p < 0.0041$), particularly those of endodontic origin without root canal fillings ($p = 0.0046$), than the control women. The general well-being of cancer patients was significantly reduced with a HADS score of 9.4 for women with breast cancer compared to 5.3 for the healthy control. This study suggests that women after breast cancer chemotherapy are inclined to have a poorer oral health status with more missing teeth and apical lesions. Therefore, tightly scheduled dental recall visits should be recommended.

Keywords Breast cancer therapy · Chronic dental infections · Missing teeth · Anxiety · Depression

Introduction

Breast cancer is the top malignant neoplasm in women and is responsible for the second greatest number of cancer-related deaths in both developed and developing countries [1, 2]. The lifetime risk of being diagnosed with breast cancer is approximately 12% in Western, industrialized countries [3]. Due to improvements in treatment regimens, the survival rates of women undergoing therapy, which includes surgery, radio/chemotherapy and/or targeted biological therapy, have significantly changed over the last few decades, with a 5-year survival rate of 86–90% [4, 5]. Secondary preventive programs, i.e., cohort mammography screens, have largely contributed to the early detection of breast cancer and a significant reduction in mortality [6]. Although the etiology of breast cancer is largely unknown, several well-known risk factors, such as genetics, increasing age, obesity, early menarche and late menopause, as well as alcohol abuse, have been identified [7]. Breast cancer comprises

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different subtypes that are determined by molecular and genetic factors, such as the expression of estrogen receptor (ER), progesterone receptor (PR), or human epidermal growth factor receptor 2 (HER2) or the absence of all three markers (TNBC—triple negative breast cancer) [8]. Currently, therapeutic approaches are tailored to the respective type of tumor, and hormonal and immunological strategies are gaining importance, although adjuvant or neoadjuvant chemotherapy still plays a major role in systemic tumor therapy [9–12]. While cytostatic drugs are highly potent, they also produce numerous side effects and complications, such as neuropathy, cardiotoxicity, liver and kidney damage and alopecia, to name a few [13–15]. Regarding chemotherapy-induced adverse effects within the oral cavity, dry mouth, xerostomia, mucositis and stomatitis are frequently observed [16–18]. However, evidence on chronic dental infections and periodontitis is extremely rare, with only a few reports on the increased likelihood of developing caries in patients undergoing systemic chemotherapy [19, 20]. Therefore, the aim of this cross-sectional study was to assess the oral health status of postmenopausal women after receiving breast cancer chemotherapy and compare it to the oral health status of age-matched controls who were treated at the university dental school for acute pain, abscesses, or gum problems and, for a very small percentage, were also seen at regular dental visits.

The main of this study focus was to assess the correlations between breast cancer chemotherapy and oral health, numbers of missing teeth and apical lesions and general well-being (HADS, hospital anxiety and depression scale). The null hypothesis was that no difference in the numbers of missing teeth and apical lesions or general well-being existed between the cancer group and the healthy controls.

Materials and methods

Sample selection

The sample sizes and power for this cross-sectional study were calculated based on the number of missing teeth as the primary endpoint, assuming that the number of missing teeth followed a Poisson distribution. In the population-based SHIP study (Study of Health in Pomerania) by Mundt et al., the median number of missing teeth in participants aged 55–59 years was nine [21]. We expected that our study participants would be somewhat older due to the age distribution of patients with breast cancer. Therefore, we based our calculations on the assumption that the healthy control group would have an average of ten missing teeth. We originally planned to compare the groups using a Wilcoxon–Mann–Whitney test at the 5% significance level and deemed an average difference of 1.5 missing teeth as

relevant. With 80 women per group, this difference would be established with a power of 80.4%.

Eighty postmenopausal women who received breast cancer therapy and were aged between 47 and 75 years (mean age 60.5 years) were enrolled in this study. We searched the archives of the Clinic for Obstetrics and Women's Health of the University Medical Center, Mainz for women who received successful treatment for breast cancer from 2004 to 2014. The subjects were contacted by letter or phone and asked to participate. If they agreed, the women were invited to undergo a thorough dental examination.

Inclusion criteria were the initial diagnosis of breast cancer (Table 1), followed by surgical therapy and additional radio- and chemotherapy. A stage T1 tumor was present in 43 (54%) of the women, 32 women (40%) had stage T2 tumors and 5 women (6%) had stage T3 tumors. Most of the women (44) had no affected lymph nodes (N0), 27 women had one positive lymph node (N1), 5 women had 2 positive lymph nodes (N2) and 4 women had 3 positive lymph nodes (N3). Women who received (supplementary/solely) endocrine or immunological therapy were excluded from this study, as were women with severe chronic diseases such as CHD, COPD or other cancers. Details about the type and length of chemotherapy were obtained from the patients' medical records.

Eighty healthy age-matched outpatients (mean age 60 years, range 48–76 years) from the Department of Operative Dentistry of the University Medical Center, Mainz, Germany, served as controls. The control patients were mostly treated for acute pain, odontogenic abscesses, or dental trauma with the need for comprehensive restorations, and some patients were allocated to the University due to the complexity of their diagnosis. We consciously chose this patient population since it represents a valid/good cross section of the German population. The consulted control women were in good general health and had no history of cancer. Women with smoking habits and diabetes mellitus were also included in this study; however, the distributions among both groups were comparable. In both patient groups, women who had less than 6 remaining teeth were excluded from this study. Inclusion criteria were also the provision of informed consent to participate in all examinations described

Table 1 Type of breast cancer and medical parameters ($n=80$ women)

Tumor history	
Invasive ductal carcinoma	62 (75.5%) women
Invasive lobular carcinoma	10 (12.5%) women
Medullary carcinoma	5 (6.25%) women
Papillary carcinoma	2 (2.5%) women
Mucinous carcinoma	1 (1.25%) woman

in the protocol, including X-ray examinations and completing questionnaires. All women were asked about their education levels (Level I: 9 years or less of schooling, Level II: 10–11 years, and Level III: 12 or more years) and they were required to complete two questionnaires about their general well-being (HADS-D) and oral health impact profile (OHIP-G14). The study was approved by the Institutional Review Board and the Ethics Committee of the University of Mainz [837.065.17(10899)] prior to patient enrollment. All women, breast cancer survivors and healthy controls, were informed verbally and in writing about the nature of the investigation, and they all provided written consent to participate. While the women who underwent breast cancer therapy were recruited and asked to attend a special appointment for their oral assessment, the healthy women were examined after dental treatment at the University Medical Center, which comprised patients with acute dental pain and patients attending regular dental appointments.

Breast cancer therapy

Prior to treatment, the medical regimen of the patients with breast cancer was discussed by the University's Breast Cancer Board, an interdisciplinary panel constituting radiologists, radiotherapists, gynecologists, pathologists and oncologists, regarding the tumor stages and general health conditions of the women. In addition to chemotherapy, the women received radiation therapy. All women received a cumulative radiation dose of 50 Gray (Gy), 16 women obtained an additional boost of 10 Gy and 33 women even received a boost of 16 Gy. Overall, 95% of the investigated women were treated using an adjuvant approach, the other 5% were treated using a neoadjuvant protocol. Thus, after or prior to surgery, all of the investigated women received chemotherapy according to the following evidence-based treatment schedules:

FEC (5-fluorouracil, epirubicin, cyclophosphamide, and docetaxel), TAC (docetaxel, doxorubicin, and cyclophosphamide), ETC (epirubicin, paclitaxel, and cyclophosphamide) and CMF (cyclophosphamide, methotrexate, and 5-fluorouracil).

Clinical examination

All women received an oral investigation performed by two experienced examiners. For the dental examination, we used a common protocol for all participants and entered the results for all parameters. Validated questionnaires were administered in identical way to all participants. Calibration with a sample size of ten patients was performed prior to the examination to obtain acceptable intra-examiner reproducibility. The dental examination included the number of teeth, caries frequency (DMFT) and an examination of

pulp necrosis using a cold thermal test. The scores for the Sulcus Bleeding Index (SBI), the Approximal Plaque Index (API) and the Periodontal Screening Index (PSI) were also recorded using a standardized periodontal probe (PCP 15, Hu-Friedy, Chicago, IL, USA). For the detection of root canal fillings and possible chronic apical lesions of periodontal (LPO) or endodontic origin (LEO) with or without root canal fillings, all women underwent a radiological examination (OPG). Teeth were graduated for apical lesions if they exhibited periapical rarefaction contiguous to the periodontal ligament space with a width of more than 2 mm and the absence of an intact lamina dura. Each patient's height and weight were recorded to calculate the body mass index (BMI). All women were further asked to complete two questionnaires, the OHIP-G14, which captures the oral health-related quality of life, and the HADS-D, which detects the general well-being. The score for the hospital anxiety and depression scale was retrieved to screen the patients after they completed cancer therapy. Anxiety is likely to sharpen the patient's health awareness, accounting for frequent consultations; on the other hand, anxiety can also lead to depression and neglect. The HASD index was calculated to provide advice on the frequency of possible recall visits and exclude one of the aforementioned effects of anxiety.

Statistical analysis

For descriptive analyses, means and standard deviations (SD) were calculated for normally distributed continuous variables, and medians and quartiles for non-normally distributed continuous variables and ordered variables. In addition, absolute and relative frequencies were computed for categorical variables. We fitted suitable generalized linear models (such as Poisson regression, linear regression and logistic regression) to determine whether breast cancer was associated with dental outcomes. We used Poisson regression for count data, such as the number of missing teeth, DMFT, number of apical lesions, number of root canal fillings, number of implants and number of capped teeth. We first fitted zero-inflated Poisson regression models. If the zero inflation parameter did not differ significantly from zero at the 20% level, we used simple Poisson regression models. This approach led to the fitting of zero-inflated Poisson regression models for the number of missing teeth, root canal fillings, number of capped teeth, number of implants and the fitting of simple Poisson regression models for DMFT and the number of apical lesions. Count data with few non-zero or extreme outcomes, such as LEO with root canal filling (0 versus > 0), LEO without root canal filling (0 versus > 0), and PSI (1–2 versus 3–4), were dichotomized and analyzed using logistic regression models; odds ratios (OR) are presented in this case. OHIP-G14 was not adequately modelled by a Poisson distribution or a normal distribution. Therefore,

we dichotomized OHIP-G14 at the 90th percentile found in the healthy reference group described by John et al. Patients with an OHIP ≤ 11 were considered as having a satisfactory oral health quality of life, and patients with an OHIP > 11 were designated as having an unsatisfactory oral health quality of life. Scores that exhibited an approximately normal distribution, such as API and HADS, were analyzed using a linear regression model. For SBI, a log-normal model was fitted. All models were adjusted for age and education, as oral health is known to be associated with age and education. We also fitted models only to patients with time since chemotherapy for outcomes, adjusting for age and education, to assess the effect of the time since chemotherapy on the number of missing teeth and apical lesions. For OHIP-G14 and HADS-D, we also adjusted for the number of missing teeth, as the quality of life and particularly the satisfaction with oral health are likely related to the number of missing teeth.

Results

In the present study, 256 women were successfully treated for breast cancer. These patients were contacted and 31% agreed to participate in this study. The primary reason patients decided not to participate in this study was a lack of interest; further reasons were a reduced overall health status, e.g., hospitalization, an earlier dental consultation and long distance to the University hospital. Overall, 80 breast cancer survivors (mean age 60.5 years; SD ± 6.2 years) were recruited for the dental assessment. The 80 healthy controls had a mean age of 60.3 years (SD ± 6.5 years). Table 2 displays the demographic characteristics of the two groups, such as age, BMI, diabetes mellitus status, smoking habits and the results of the HADS-D and OHIP-G14 questionnaires.

The dental examination confirmed an unfavorable oral health status of women who received breast cancer treatment compared to the oral health status of the control group (Table 3). The median number of missing teeth was 3 (IQR 1–5) in the breast cancer group, whereas it was only 1 (IQR 0–2) in the control group. This difference was statistically significant ($p < 0.0001$), on average a 2.81-fold (95% CI 2.14; 3.69) increase in the number of missing teeth in the breast cancer group—adjusting for age and education. Further factors influencing the number of missing teeth were education ($p < 0.001$) and age ($p = 0.0017$). The influence of education on both groups is clearly visible, as displayed in Fig. 1. Expected numbers of missing teeth in women with the lowest education level are 1.98-fold (95% CI 1.40; 2.78) higher than the number expected in women with the highest education level, and expected number of missing teeth increased by 2.8% (95% CI 1.1%; 4.7%) per year of age.

Table 2 Comparison of baseline variables between women after breast cancer ($n = 80$) and healthy control women ($n = 80$)

Variables	Women groups		
	After breast cancer	Controls	<i>p</i> value*
Age (year)	60.5 (± 6.2)	60.3 (± 6.5)	0.5671 ^a
BMI (kg/m ²)	25.3 (± 5)	23 (± 3)	0.3139 ^a
OHIP-G14	5 (0–10)	2 (0–5)	0.1877 ^b
HADS-D	9.4 (± 6.7)	5.3 (± 4.2)	0.0044 ^{b,*}
Smoker (%)	28 (35%)	24 (30%)	0.7175 ^c
Diabetes mellitus (%)	7 (8.8%)	6 (7.5)	1.0000 ^c

The table depicts the mean \pm SD (standard deviation) or median (Q1–Q3, quartile deviation) for quantitative variables and absolute and relative frequencies for dichotomous variables

BMI body mass index, HADS-D Hospital Anxiety and Depression Scale, OHIP-G14 Oral Health Impact Profile

^aWilcoxon test

^bAfter adjusting for missing teeth, education level and age

^cFisher's exact test. The significance level is $\alpha = 0.05$, significant results are denoted with*

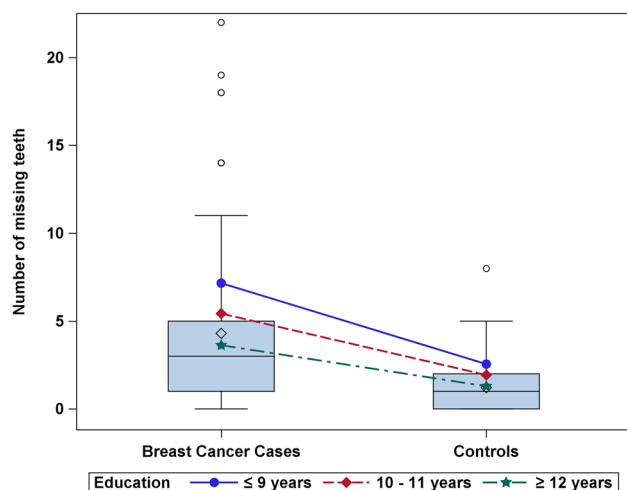
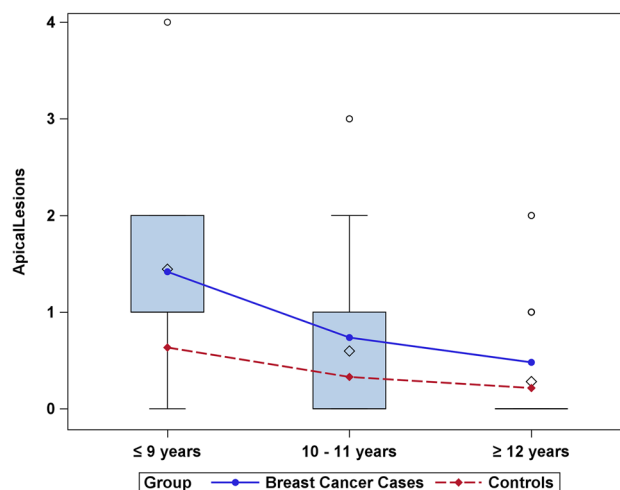
The analysis of DMFT pointed in the same direction. In the patient group, the median index for caries frequency (DMFT index) was 19 (IQR 16–22), which was significantly higher [$p = 0.0093$, factor 1.12, 95% CI (1.03; 1.21) adjusting for age and education] than the values of the control group (median 16.5, IQR 12–19). Again, low education levels [$p = 0.0409$, factor 1.19, 95% CI (1.01; 1.41)] and age [$p = 0.0038$, 0.9% per year, 95% CI (0.3%; 1.5%)] significantly influenced the DMFT values.

A substantial difference in the number of root canal fillings was not observed between the two groups, with a median of one root canal filling (IQR 1–3) in the breast cancer group and one (IQR 0–2) in the controls; factor 1.0 95% CI (0.73; 1.36). The only influential factors were the woman's age [$p = 0.039$, 2.2% per year, 95% CI (0.1%; 4.4%)] and a low education level [$p = 0.0078$, factor 2.01, 95% CI (1.30; 3.36)]. However, women with cancer showed a significantly greater number of apical lesions ($p = 0.0041$) on average 2.24-fold [95% CI (1.29; 3.87)]. Basically, those lesions were distinguished according to the origin of their inflammation. Lesions of endodontic origin (LEO) are differentiated from lesions of periodontal origin (LPOs) in cases where probing depths and periodontal disease are present. In combined cases, respective lesions were recorded as LEO. Furthermore, a distinction between LEOs with or without a root canal filling was made. The age of the women had no influence of the number of apical lesions [$p = 0.1875$, factor 1.02, 95% CI (0.99; 1.06)], but a significant effect of a low education level was observed [$p = 0.0068$, factor 2.95, 95% CI (1.35; 6.45)] (Fig. 2). The number of LPOs was generally low and therefore negligible for the statistical analysis. In the breast cancer group, more patients had

Table 3 Comparison of dental variables in women after breast cancer chemotherapy ($n=80$) and healthy control women ($n=80$)

Dental values	Women groups		
	After breast cancer	Controls	p value*
DMFT	19 (16–22)	16.5 (12–19)	0.0093*
Missing teeth (n)	3 (1–5)	1 (0–2)	<0.0001*
Root canal filling (n)	1 (1–3)	1 (0–2)	0.9938 (n.s)
Apical lesions (n)	1 (0–1), max = 4	0 (0–0), max = 2	0.0041*
LEO with root canal filling	22 (28%)	15 (19%)	0.3539 (n.s)
LEO without filling	4 (5%)	25 (31%)	0.0046*
API (%)	53 (\pm 22)	39 (\pm 14)	0.0062*
SBI (%)	31 (\pm 19)	23 (\pm 11)	0.0314 *
PSI 3–4	47 (59%)	35 (44%)	0.5275 (n.s)

The table depicts the mean \pm SD (standard deviation) or median (Q1–Q3) for quantitative variables and absolute and relative frequencies for dichotomous variables. The p values are for testing the hypothesis that regression coefficient for group is zero in the generalized linear model. $\alpha=0.05$, significant results are denoted with*

**Fig. 1** Box plots depicting the distribution of missing teeth among women who received breast cancer therapy and controls. The lines show the expected numbers derived from the model at the age of 60.4 years (mean age of the total population) in patients stratified by education level. Level I: ≤ 9 years, Level II: 10–11 years, and Level III: ≥ 12 years**Fig. 2** Box plots depicting the distribution of the number of apical lesions (LEOs and LPOs) in women stratified by education levels (Level I: ≤ 9 years, Level II: 10–11 years, and Level III: ≥ 12 years). The lines show the expected numbers derived from the model at the age of 60.4 years (mean age of the total population) stratified by women with breast cancer and controls

LEOs without root canal fillings (31%) than with root canal fillings (19%) (Table 3). Patients with breast cancer were more likely to have at least one LEO without a root canal filling [OR = 5.85; 95% CI (1.73; 19.84), $p=0.0046$], a difference between the lowest and highest education levels was also observed [OR = 6.84, 95% CI (1.13; 41.18), $p=0.0359$]. However, the frequency of LEOs with root canal fillings did not differ significantly between groups [OR = 1.48, 95% CI (0.65; 3.38), $p=0.3539$] and was not related to age or education. Regarding the Sulcus Bleeding Index (SBI), patients with cancer showed significantly more bleeding points than the controls [1.24-fold, 95% CI (1.02; 1.51), $p=0.0314$], and again, a considerable effect of a low education level

[1.82-fold, 95% CI (1.37; 2.42), $p<0.0001$], but not the age of the women ($p=0.0541$), was identified (Fig. 3). The same situation applied for the Approximal Plaque Index (API). Patients with cancer showed significantly higher API values—on average 8.3 higher [95% CI (2.4; 14.3), $p=0.0062$], and the influence of the education level was significant [on average 30.6 higher, 95% CI (17.7; 43.5), $p<0.001$ for lowest versus highest level]. No difference in the Periodontal Screening Index (PSI) was observed between the two groups of women [OR = 1.25, 95% CI (0.62; 2.53), $p=0.5275$].

The breast cancer survivor groups were more likely to show signs of anxiety and depression (9.4, SD \pm 6.7) than healthy women (5.3, SD \pm 4.3), as recorded by the Hospital

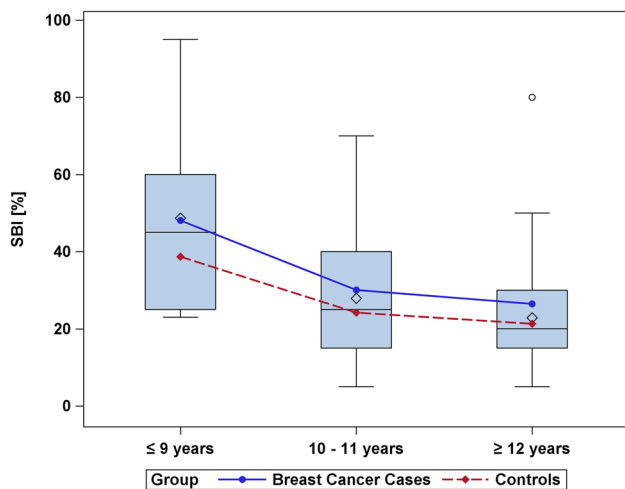


Fig. 3 Box plots depicting the distribution of gingival bleeding points (SBI) in women stratified by education level (Level I: ≤ 9 years, Level II: 10–11 years, and Level III: ≥ 12 years). The lines show the expected numbers derived from the model at the age of 60.4 (mean age of the total population) after stratification by breast cancer and control statuses

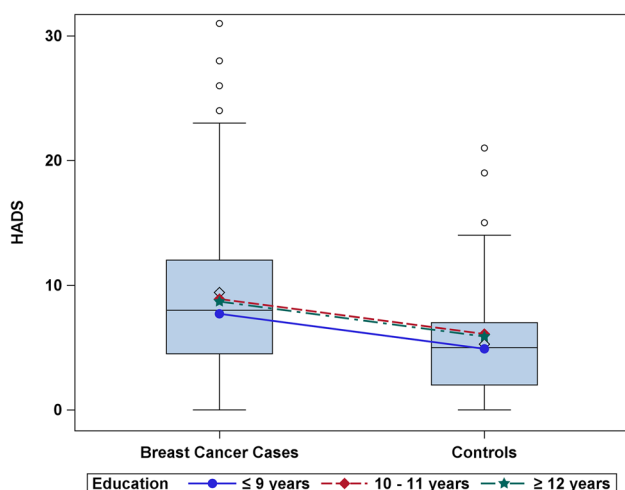


Fig. 4 Box plots depicting the distribution of HADS values for women who received breast cancer therapy and controls. The lines show the expected numbers derived from the model at the age of 60.4 years (mean age of the total population) after stratification by education level. Level I: ≤ 9 years, Level II: 10–11 years, and Level III: ≥ 12 years

Anxiety and Depression Scale (HADS-D) questionnaire, and this effect was significant ($p = 0.0044$), the mean difference after controlling for age, education and number of missing teeth was 2.8, [95% CI (0.9; 4.7)]. Among all study participants, the number of missing teeth had a significant effect on the HADS-D values ($p = 0.0002$)—on average 0.5 points per missing tooth [95% CI (0.2; 0.7)]. However, education levels or the age of the patients had no detectable effect on the HADS-D score (Fig. 4).

Breast cancer survivors had a median OHIP-14 score of 5 (IQR 0–10), whereas healthy controls had a median score of 2 (IQR 0–5). This value corresponded to 2 (3%) controls and 16 (20%) breast cancer survivors reporting OHIP-14 scores of greater than 11. However, after adjusting for the number of missing teeth, which was higher in the breast cancer group, no significant group effect was observed [OR = 3.14, 95% CI (0.57; 17.19), $p = 0.1877$]. The dental examination of the patients with cancer occurred in a time frame ranging from 3 to 10 years after the initial diagnosis and therapy of the respective breast cancer type. Although this time frame seems quite long, no association between time since chemotherapy and number of missing teeth [0.9% increase, 95% CI (− 1.7%; + 3.6%), $p = 0.4803$] or apical lesions [4.8% increase per year, 95% CI (− 1.7%; + 11.7%), $p = 0.1491$] were observed after adjusting for age and education.

Discussion

With 1 in 8 women in western industrialized countries being diagnosed with breast cancer in her lifetime and survival rates of over 80% after 10 years, the long-term adverse effects of breast cancer therapy are increasing in importance [2, 22]. While numerous reports on the systemic side effects of chemotherapy have been published, evidence of its impact on oral health, apart from mucositis and stomatitis, is extremely rare. Therefore, the present study focused on assessing the oral health status of a large number of postmenopausal women after successful breast cancer chemotherapy and therapeutic radiology. A particular focus was the possible relation between breast cancer chemotherapy, chronic odontogenic infections and pulp irritations resulting from possible chemotherapy-induced neuropathy. Women who received additional hormonotherapy were excluded. Furthermore, the oral health-related quality of life and levels of anxiety and depression were assessed using the OPHIP-G14 and HADS-D questionnaires, respectively.

Depression and anxiety have negative impacts on self-care, including oral hygiene habits, and may eventually lead to a higher prevalence of periodontal disease, caries and tooth loss [23, 24]. Numerous studies have reported that women undergoing cancer therapy experience a significant reduction in quality of life and suffer from depressive symptoms [25, 26].

In our study, the cancer group achieved significantly higher HADS-D scores than the healthy controls. OHIP-G14 scores were also higher, but not significantly different after adjusting for the number of missing teeth, which in turn was higher in breast cancer survivors. Similar observations were reported by Pereira et al., who assessed the oral health-related quality of life in 30 patients with cancer and concluded that changes in oral physiology impact oncological

patients' quality of life [27]. These findings contradict the results from the study by Taichman et al., who reported that patients with cancer had a more positive perception of their quality of life than healthy controls [20].

Regarding the dental parameters, cancer survivors proved to have higher plaque values and more gingival bleeding and an increased likelihood of developing gingivitis. These findings are supported by the study by Amodio et al., who showed elevated levels of periodontitis and missing teeth in a cohort of 48 patients with breast cancer compared to 48 healthy, age-matched controls [23]. However, in this study, a radiological examination was not conducted, and the breast cancer group was rather inhomogeneous since patients who received chemo-, anti-hormonal and immunotherapy were included.

In our study, we included a relatively large number of 80 postmenopausal patients with breast who solely received combined radio- and chemotherapy and compared them to 80 women without a history of cancer.

The control group comprised women who consulted the University Dental School for pain, an accident, abscesses, or in some cases only for a dental visit or control. Dental treatment at the university clinic is very popular because dental treatments are generally cheaper and emergency appointments are easier to obtain. Certain limitations exist regarding the recruitment of the control patients. Those women might be allocated to the university clinic due to the complexity of their oral disease, which might imply a very bad oral health status. On the other hand, women who are very health conscious likely seek treatment from a university since the clinic covers a broad therapeutic spectrum and the treatment regime is evidence-based. Therefore, a certain bias regarding the control group cannot be completely neglected; however, we focused on selecting a control group that represents a cross section of the German population.

Only one-third of the patients with cancer who were contacted agreed to participate in this study. Again, this proportion represents a special population of women who are devoted to their oral health, and thus the bias in the groups seems comparable.

Patients with cancer had greater numbers of missing teeth and apical lesions, particularly lesions of endodontic origin. According to Taichman et al., a woman's estrogen status modulates the health of soft tissues within the oral cavity, as well as alveolar bone density and tooth loss. Hence, when women have conditions characterized by decreased hormonal activity, such as menopause, or receive chemotherapy and immunotherapy, the odds of developing gingivitis and losing teeth are substantially increased [28].

Chemotherapy further causes a bacterial shift and an imbalance within the oral flora towards a more complex and harmful bacterial profile [29]. These more virulent pathogens might further exacerbate ongoing bacterial processes.

The increased number of apical lesions detected in the breast cancer survivors might be due to a higher bacterial virulence combined with a depressed immune system. Neuropathy, a well-known side effect of chemotherapy, might also influence pulpal tissues and result in an increased loss of pulp vitality. This loss of vitality leads to chronic apical lesions that significantly reduces the success rates of root canal fillings and might even result in tooth loss.

In our study, the cancer group had a greater number of missing teeth and a significantly increased number of apical lesions, particularly lesions of endodontic origin without root canal fillings.

While further clinical studies are needed to verify these findings, current evidence suggests that chemotherapy-induced neuropathy, a bacterial shift within the oral cavity and a reduction in oral care due to depressive symptoms might be possible explanations.

In conclusion, the present study examined the possible association of breast cancer therapy, particularly chemotherapy, on the oral health status of 80 postmenopausal women. Breast cancer survivors had a significantly greater number of apical lesions, particularly lesions of endodontic origin, without root canal fillings and more missing teeth than the healthy controls. Regarding the clinical consequence, we recommend that women who have received chemotherapy for breast cancer should be considered high-risk patients and therefore enrolled in a strict dental recall system. In patients whose initial signs and symptoms suggest pulpal inflammation, a root canal treatment should be performed to prevent apical lesions and chronic odontogenic infections, which ultimately lead to tooth loss.

Because only a few studies have been published that address the topic of oral health in breast cancer survivors and our study employed a cross-sectional design, the generalizability of the findings is limited. More conclusive results require further investigations of a more comprehensive cohort.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

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