

Dental therapy before and after radiotherapy—an evaluation on patients with head and neck malignancies

Sabine Sennhenn-Kirchner · Friederike Freund ·
Sven Grundmann · Alexios Martin ·
Margarete Borg-von Zepelin · Hans Christiansen ·
Hendrik Andreas Wolff · Hans-Georg Jacobs

Received: 7 June 2008 / Accepted: 22 September 2008 / Published online: 17 October 2008
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Abstract The present investigation evaluates the dental care situation of patients with head and neck cancer before and after radiotherapy. The situations of these patients in 1993 and 2005 were compared to detect similarities, differences and developments. In the years 1993 and 2005, 37 and 36 patients, respectively, with head and neck cancer treated by the local departments of otorhinolaryngology and of radiotherapy were examined consecutively according to their aftercare appointments. Time points of radiotherapy treatment of the patients evaluated in 1993 varied from 1984 to 1993. The patients evaluated in 2005

had received radiotherapy between 1998 and 2005. Therefore the applied radiotherapeutic regimen differed not only between the two groups of patients, but also within each group. The information for these investigations was provided anonymously. It was evaluated with descriptive statistics. The evaluation of the data shows distinct differences with respect to preventive and therapeutic dental care measures. In 2005, 35 out of 36 patients (97.2%) had a dental consultation before radiotherapy (1993, 65%). All 27 dentate patients (100%) obtained a splint for fluoride application (1993, none). 29% fewer edentulous patients were seen than in 1993. The number of teeth destroyed decreased from 19.2% (1993) to 7.8% in 2005. Mycoses due to *Candida* spp. and chronic failures in wound healing were rare (5.5%). In the course of the 12 years, prophylactic measures, such as the application of splints for fluoride treatment, were intensified. However, concepts for the dental care of patients undergoing radiotherapy, especially following the radiation, should be widened to avoid ruined teeth and long delayed wound healings.

S. Sennhenn-Kirchner
Department of Oral- and Maxillofacial Surgery,
University Medicine Goettingen,
Göttingen, Germany

F. Freund · S. Grundmann · H.-G. Jacobs
Department of Oral Surgery, University Medicine Goettingen,
Göttingen, Germany

A. Martin
Department of Otorhinolaryngology,
University Medicine Goettingen,
Göttingen, Germany

M. Borg-von Zepelin
Institute for Microbiology, University Medicine Goettingen,
Göttingen, Germany

H. Christiansen · H. A. Wolff
Department of Radiotherapy, University Medicine Goettingen,
Göttingen, Germany

S. Sennhenn-Kirchner (✉)
Abteilung für Mund-, Kiefer-, Gesichtschirurgie,
Robert-Koch-Str. 40,
37075 Göttingen, Germany
e-mail: se.ki@med.uni-goettingen.de

Keywords Radiation caries · Prevention · Radiotherapy · Radiation sequelae · Osteonecrosis · Fluoride application · Mucositis

Introduction

Tumours of the oral and maxillofacial region constitute more than 5% of all tumours worldwide with increasing incidence [19].

The therapy of malignant tumours in the oral and maxillofacial region is multimodal with curative potential in the non-metastatic situation including surgery that is followed by adjuvant radio(chemo)therapy in case of locally

advanced tumours (UICC III/IVA/B), or primary radio (chemo)therapy. A fundamental aim of the radiotherapy is the local control of the tumour. The improvement in local control leads to an amelioration of the survival rate in the ideal case [20, 28]. In the case of locally advanced tumours of head and neck, multimodal therapeutic concepts are performed using simultaneous radiochemotherapy with or without surgery [7, 19, 30].

All effects of X-rays pathologically influence the ecology of the oral cavity. Radiotherapy impedes the restoration of functional rehabilitation [12]. Prophylaxis and therapy need a close collaboration between surgeons, radiotherapists and dentists [2, 4, 34].

In the oral cavity, degenerative and inflammation processes are observed. These processes lead to tissue destruction caused by changes in the microflora and reduction of the local and general defence [23, 42].

As an early radiation effect, the radiation-induced mucositis is the most important side effect. As late side effects, radiation-induced xerostomia, often long lasting, and radiation-induced caries, resulting dental extractions and the risk of osteoradionecrosis (ORN) are especially significant [12]. The severity of mucositis caused by radiotherapy is dependent on the level of oral hygiene [37]. Therefore, prophylaxis and therapy are important components during radiation. Complicated radiomucositis can result in an abruption of the therapy and an important treatment tool has to be abandoned [19, 36, 41].

The level of radiation-induced caries due to xerostomia can be limited by optimal concepts of oral hygiene [27]. In the case of a lack of oral hygiene, an indication for dental extraction occurs. The amount of extraction is a matter of controversial debate [3, 9, 11, 16, 33]. Many authors recommend selective indications for extraction. For example, Coffin [5] and Horiot et al. [18] propose a more conservative strategy to save as many of the patient's teeth as possible and, thus, preserve a better quality of the life of the patient.

Due to an increased fragility of oral mucosa, only exactly fitting dentures should be worn during radiation treatment and thereafter, exclusively during meals. The complication rates caused by defects of the oral mucosa are high. Therefore, the exclusion of pressure sore beneath partial and total dentures is particularly important [31, 38].

The importance of dental extraction, prior to radiation, has been proven by results of studies on infected osteoradionecrosis (IORN incidence) indicating that in 60–90%, dental causes are responsible [8, 12]. The therapy of osteoradionecrosis (ORN) must be performed by specialists and exceeds the fields of duty of dentists. Prophylactic measures for this severe complication represent the best therapy [22], therefore, the dentist's activity, especially with respect to prevention and early diagnostics, is particularly important.

The aim of the present investigation is the evaluation of changes in the dental care of patients from the Department of Otorhinolaryngology (ORL) after radiotherapy of head and neck by a comparison of dental findings documented in 1993 and in 2005.

Materials and methods

Two groups of patients who had follow-up examination in the Department of ORL after being irradiated for head and neck cancer were dentally examined in 1993 ($N=37$) and 2005 ($N=36$). The patients received radiotherapy for their tumour disease in the head–neck area and the aftercare was performed by the Department of Radiotherapy and the Department of ORL, University Medicine Goettingen. Time points of radiotherapy treatment of the patients evaluated in 1993 varied from 1984 to 1993. The patients evaluated in 2005 had received radiotherapy between 1998 and 2005. Therefore, the applied radiotherapeutic regimen differed not only between the two groups of patients, but also within each group. The interval between radiotherapy and dental examination had a median of 25.9 months (range 1.2 to 122.8 months) for the first group (examined in 1993) and a median of 20.1 months (range 1.0 to 99.4 months) in the second group (examined in 2005), respectively.

Both groups examined are rather small compared to the time sequence of 10 and 8 years. As a matter of course, more patients received radiotherapy of the head and neck region in the respective periods, approximately between 20 and 40 patients per year. A high number of these patients do not undergo regular head and neck aftercare at the ORL Department but at an external located ORL specialist. These patients could not be recruited for the study. Furthermore, many patients refused to participate in our study for several reasons or were not compliant. Above all, the period of the examinations was limited to 4 months in 1993 and 2005.

After a general anamnesis, the patients were questioned on the course of dental therapy before, during and after radiotherapy. Thereafter, detailed extraoral and intraoral examinations were performed. Besides the systematic evaluation of the data with the help of an anamnesis scheme (Fig. 1), subjective estimations of the patients with regard to oral mucosa, salivation, temporomandibular joints (TMJ) and function of dentures were recorded.

The evaluating physicians were not the same in 1993 and in 2005, but each patient group was examined by one person. Supervision and calibration of these evaluators was performed by the deputy, an oral surgeon.

The data of the different tumour diseases and the course of therapy were drawn from the patients' dossiers.

In 2005, 15 patients (41.6%) had received additional chemotherapy with cisplatin, carboplatin, mitomycin, 5

Fig. 1 Anamnesis scheme for the evaluation of the dental course of therapy before and after radiotherapy

before radiotherapy					
dental consultation	no	yes →	dental clinic	no	yes
			local dentist	no	yes
			both	no	yes
dental therapy	no	yes →	extractions	no	yes
			oral surgery	no	yes
			restorative procedures	no	yes
			prosthetic procedures	no	yes
			splints for fluoride application	no	yes
			periodontological procedures	no	yes
			other therapies	no	yes
after radiotherapy					
dental consultation	no	yes →	dental clinic	no	yes
			local dentist	no	yes
			both	no	yes
dental therapy	no	yes →	extractions	no	yes
			oral surgery	no	yes
			antibiotic regimen with extractions/surgery?	no	yes
			restorative procedures	no	yes
			prosthetic procedures	no	yes
			splints for fluoride application	no	yes
			periodontological procedures	no	yes

fluorouracil or bleomycin or various combinations of these (1993, 67.5%).

In both series of investigation, most of the patients conceded a misuse of alcohol and tobacco. Most often, the patients complained of the partly considerable oral xerostomia. Additionally, problems with removable dentures and unspecific oral pain were stated.

Higher grade acute side effects (\geq grade 2 mucositis/dysphagia/skin reaction according to CTC score) during radio(chemo)therapy as retrospectively evaluated occurred in 40% of all patients. The number of patients who consulted a dentist prior to radiotherapy distinctly increased from 65% in 1993 to 97% in 2005. The therapeutic measurements performed prior to radiotherapy distinctly differed in their frequencies in both series of investigation (Fig. 2). It has to be pointed out that in the year 1993, none of the partially dentate patients and in the year 2005 all 27 patients (100%) were provided with splints for fluoride application.

The number of patients who regularly consulted their local dentist after radiotherapy also differed from 57% in the year 1993 to 86% in 2005. The majority of these patients went to local dentists. The therapeutic measures performed after radiotherapy differed mainly with respect to procedures for tooth extraction, prosthetic therapy and fluoride application (Fig. 3). In 1993, teeth of 12 patients had to be removed (57.1%). In 2005, this procedure was

performed in only seven cases (24.1%). Prosthetic therapies occurred with 14 patients in 1993 and in 2005. In 1993, no fluoride gels were administered, while in 2005, only seven out of 27 dentate patients (25.9%) received fluoride gels.

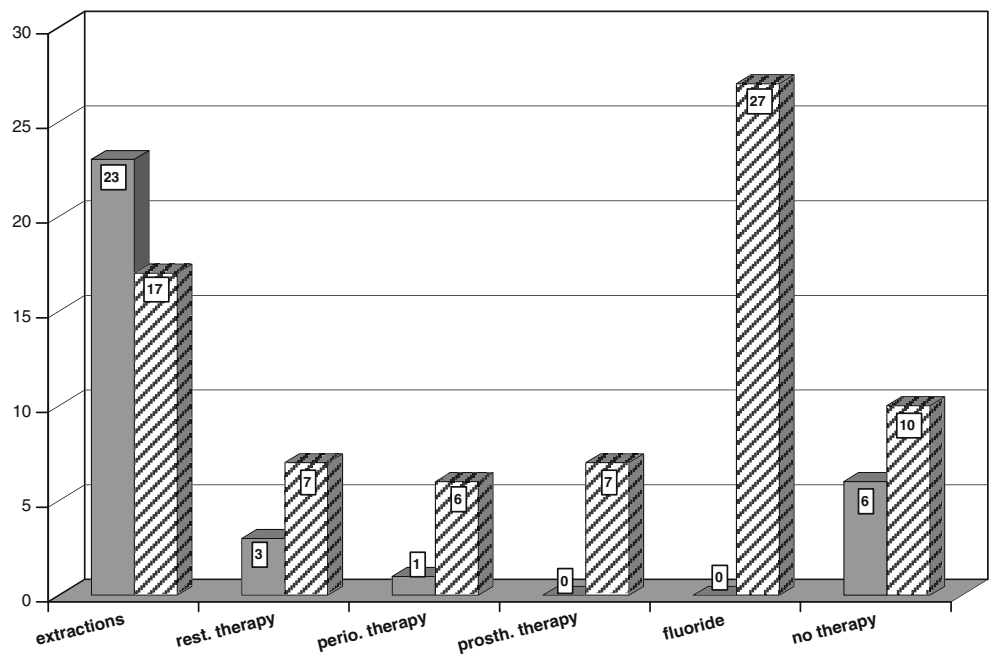
Dental evaluation

The evaluation of clinical findings was based on extraoral and intraoral examination. This included the exploration of the TMJs, the facial skin, the testing of the *N. trigeminus* and *N. facialis*, the estimation of the degree of mouth opening, the status of gingival and oral mucosa as well as the teeth and the periodont. The prosthetic superstructures were examined for functional capability and hygiene options.

The dental records were described on the basis of the DMFT indices (D = decayed, M = missed, F = filled, T = teeth) [15]. This corresponded to the mean number of teeth badly decayed (DT index), teeth missing (MT index) and teeth supplied with restorations or with fixed prosthetic superstructures (FT index).

To objectify the oral hygiene status, the plaque index (QHI), according to Quigley and Hein [29], modified by Turesky [40], was measured. The vestibular and oral surfaces of the teeth determined by Ramfjord [15] were stained and the degree of affliction with plaque was estimated.

Fig. 2 Surgical and restorative procedures *before* radiotherapy. The spectrum and the number of the different therapeutic measures (extraction of teeth, rest.: restorative, perio.: periodontological and prosth.: prosthetic therapies, fluoride: manufacture of splints for fluoride application to no therapy: no prophylactic and therapeutic measures) is demonstrated for 1995 (plain-coloured bars) and for 2005 (striped bars). With some patients, multiple therapeutic measures were performed



The status and the requirements of therapy of the periodontium were evaluated based on the Community Periodontal Index of Treatment Needs (CPITN)/Parodontal Screening Index (PSI) using the appropriate standardised periodontal probe. These indices were developed by the World Health Organisation WHO [1, 25].

Dental X-ray diagnostics

Some of the patients with corresponding findings (badly decayed or even destroyed teeth, increased mobility of teeth, signs of inflammation or symptoms with unclear allocation) were diagnosed by dental panoramic tomography.

Evaluation of the dental requirements for therapy

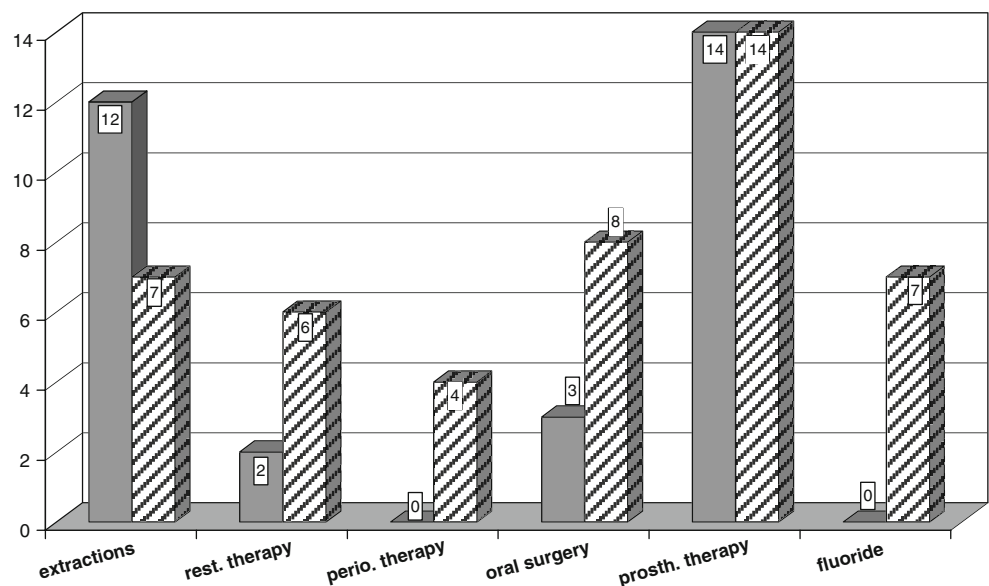
Based on anamnesis, clinical and X-ray findings, the demand for restorative, prosthetic, periodontological and/or oral surgical therapy was estimated.

The study was a historical comparison between the two different groups of patients examined in 1993 and 2005.

Results

Time points of radiotherapy treatment of the patients evaluated in 1993 varied from 1984 to 1993. The patients

Fig. 3 Dental therapeutic measures *after* radiotherapy. The spectrum of dental therapy following radiotherapy (extraction of teeth, restorative, periodontological, oral surgical and prosthetic therapies, as well as the administration of fluoride gels) is shown for 1993 (plain-coloured bars) and for 2005 (striped bars). With some patients, multiple therapeutic measures were performed. Abbreviations can be found in the legend to Fig. 2



evaluated in 2005 had received radiotherapy between 1998 and 2005. Therefore, the applied radiotherapeutic regimen differed not only between the two groups of patients, but also within each group. In 1993, 78% male and 22% female patients were examined. The mean age was 54.8 years (range 29 to 82 years). In 2005, 92% male and 8% female patients were seen. Their mean age was 57 (range 41 to 86 years).

The number of patients with removable dentures and the ratio of total dentures to partial dentures distinctly differed between the two observation time points. In 1993, 37 maxillae and 37 mandibles were examined. Out of this group, 63 jaws were treated with removable dentures. Twenty jaws (31.7%) received partial dentures, 44 jaws (69.8%) were treated with total dentures. In 2005, 50 jaws were treated with removable dentures. Out of this group, 27 jaws (54%) received partial dentures and 23 (46%) jaws, total dentures. The evaluation of the dentures considered to be sufficient in 1993 revealed 41 out of 63 removable dentures and in 2005, all 50 dentures examined.

When the oral hygiene of partially edentulous patients was compared for the observation years, it could be demonstrated that, in 2005, the oral hygiene had improved. The majority of patients in 1993 (64.6%) showed a QHI value >3. In contrast, 66.6% of all patients examined in 2005 showed a QHI value <2 (Fig. 4). The Community Periodontal Index of Treatment Needs (CPITN) or the periodontal screening index (PSI) [1, 25], respectively, showed in both series of examinations comparable mean results (1993, 3.5; 2005, 3.4). In 1993, a maximal value of 4 was measured in 52.9% of the partially edentulous patients examined, in 2005, this rate was 47.3%.

The mean DMFT indices gained in the observation years revealed comparable values. However, when the different elements were analysed separately, distinct differences were observed. For example, in 1993, 20 patients were edentu-

lous (54%) while in 2005, only nine patients (25%) were affected. All other patients were partially edentulous with a mean missing teeth index (MT) of 13.2 (1993) and 10.3 (2005). The residual dentition showed partially insufficiently restored carious lesions; 20.6% of the residual teeth were carious in 1993, in contrast only 10.8% of the residual teeth were carious in 2005.

Following these results (Fig. 4, Table 1), multiple therapeutic regimens (restorative, prosthetic, periodontologic and tooth extraction therapies) were necessary later. Only six out of 20 partially edentulous patients required no further dental treatment in 1993. In 2005, ten out of 27 partially edentulous patients did not need any dental intervention. Between the two observation time points, no obvious differences were observed.

Discussion

The data gained from the dental follow-up examinations of patients who received radiotherapy due to tumours in the head and neck area clearly demonstrate differences in dental preventive measures and follow-up therapies between the observation time points 1993 and 2005. Most of the results show positive changes in cancer patients, induced by an intensified cooperation among ORLs, radiotherapists and dentists. Today almost every patient consults a dental clinic before radiotherapy and receives distinct therapy. Every fully or even partially dentate patient is provided with splints for fluoride application. These rates are comparable to the results of Barker et al. [2] who performed a worldwide survey and found a dental consultation rate of 75% as a mean.

The further treatment of patients during and after radiotherapy is continued by local dentists. This study did not evaluate whether these colleagues have concepts for the aftercare of irradiated patients. An aspect which has to be

Fig. 4 Oral hygiene index according to Quigley–Hein (QHI). The QHI was collected from 17 patients in 1993 (plain-coloured bars) and from 15 patients in 2005 (striped bars). A value <1.5 is considered to be a good oral hygiene status and a value >4 is classified as desolate. The year 2005 reveals a distinctly better mean oral hygiene situation

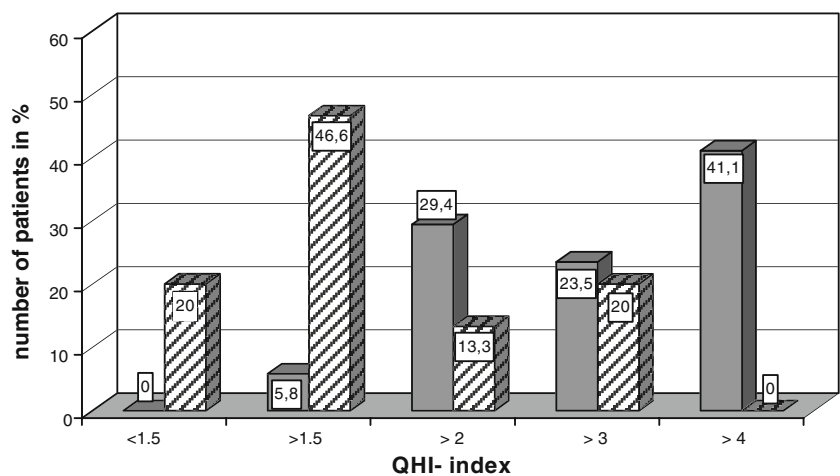


Table 1 Summary of the patients' data

		1993	2005
Alcohol and tobacco abuse	Before radiotherapy	84.4%	86.1%
	After radiotherapy	26.7%	36.1%
Predominant subjective complaints	problems with dentures	28.3%	11.1%
	Oral pain	12.4%	8.3%
Extraoral findings	Trism	52.8%	11.1%
	Paresthesias	–	25%
Intraoral findings	<i>Candida</i> mycoses	2.4%	2.7%
	Leukoplacia	2.9%	–
	Transitory mucositis	No information	72%
	IORN	–	2.7%
X- ray diagnostics	Marginal periodontitis	24.6%	16.6%
	Apical periodontitis	19.3%	16.6%
	Cysts of the maxillary sinus	2.6%	2.7%
	Residual roots of teeth	11.4%	2.7%

The subjective complaints of the patients as well as extraoral, intraoral and radiological statements are listed from both observation years

optimised is the rarely performed fluoride application of the dentate patients after radiotherapy. Its relevance has been emphasised by Grötz [12], Vissink et al. [41] and others. The risk of development of periodontal disease and, consequently, ORN is diminished in patients receiving topical fluoride applications and also maintaining good oral hygiene [41]. On the basis of the present results, a demand for further education is evident, especially a transfer of head-neck-tumour patients to special care programs is needed as is performed for patients after transplantation for example [14, 21, 27, 32]. Consolidated and collective concepts of all involved disciplines are now important [2, 6].

Compared to 1993, in 2005, distinctly fewer patients with total dentures were evaluated. The same observations were found in the two latest German studies of oral health [26]. The low number of patients with total dentures represents a positive development and satisfaction with the dentures resulted in an increased life quality of the patients [5, 18, 41]. This fact can be combined with the higher number of restored teeth. It has to be emphasised that the clinical evaluation of processes and requirements of periodontal therapy have further developed and changed [24, 43]. However, more marginal and apical periodontal infections were diagnosed. One reason might be a gap in communication between clinic and local dentists who predominantly performed the dental care after radiotherapy. It must be noted that 94% of the patients consulted the dentist before radiotherapy, however, only 53% of the patients received dental care after the radiotherapy. Radiotherapy especially reduces the state of periodontal health [24].

Despite the lower ratio of tooth extractions in 2005, the rate of radiogene caries and *Candida* mycoses did not increase. The impaired local defence of the patients with radiotherapy combined with ulcers of the oral mucosa are

factors which lead to severe *Candida* infections. During the last two decades, the *Candida* infections reached fourth position in nosocomial-blood-stream infections in the USA. This is caused by an increased number of patients with immunodeficiency due to aggressive therapies, e.g., high dose radiotherapy [10].

The investigations from 1993 and 2005 were performed by differently composed investigator teams, although calibrated by the same group leader. Therefore, subjective critical judgements should be interpreted and compared with restraint. Additionally, the investigations were carried out retrospectively. The collectives explored represented heterogeneous groups with different initial situations according to prevention and aftercare. These conditions rendered direct comparison between therapeutic processes and therapeutic regimens more difficult despite a systematic evaluation of the data. Furthermore, radiotherapy techniques changed over the years. The establishment of CT-based three-dimensional treatment planning during the 1990s has offered more possibilities for sparing normal tissue during radiotherapy and therewith for decreasing the risk of developing radiation-induced side effects. This has to be taken into account when comparing the results of patients treated between 1984 and 1993 and patients treated between 1998 and 2005. In the future, by the increased use of modern radiotherapy treatment techniques like intensity-modulated-radiotherapy (IMRT) the therapeutic index will be potentially further increased.

All peri-radiotherapeutic procedures mentioned were only effective with a good compliance of the patients [12, 39]. It must be taken into account that it is now generally accepted that all teeth with a questionable prognosis must be extracted at least 10 to 14 days prior to radiotherapy. The less motivated the patient is for oral hygiene the more extensive

one should be in extracting teeth [41]. The results of this study confirm the concept of extractions adapted to requirements [5, 17]. However, the time slot before the start of the radiotherapy is often too short for the different dental treatments demanded [35].

Many patients with head and neck tumours have problems of addiction according to nicotine and alcohol [38]. On the other hand, the acceptance and the ability of many of these patients to perform oral hygiene is low. This is an important factor stated in the a collective statement of DGZMK (Deutsche Gesellschaft für Zahn-Mund und Kieferheilkunde) and German Society for Radiooncology, medical physics and radiation biology (DEGRO) [13]. It must be taken into account for the planning of the radiotherapy because the rate of complications is correlated to the oral hygiene [13, 41].

Conclusions

Most of the study results show positive changes with cancer patients induced by an intensified cooperation among ORLs, radiotherapists and dentists between the observation time points 1993 and 2005. Nowadays, almost every patient consults a dental clinic before radiotherapy and receives distinct therapy, but only 53% of the patients received dental care after radiotherapy. An aspect which has to be optimised is the rarely performed fluoride application of partially edentulous patients after radiotherapy. The results of this study confirm concepts for extractions adapted to the requirements and underline the importance of conceptual cooperation and, in particular, the communication among ORL departments, radiotherapists, dental clinics and local dentists.

Acknowledgements The authors would like to express their appreciation to Cyrilla Maelicke (Department of Cell Biology, University of Goettingen) for critical review of the manuscript and linguistic assistance. This work comprises parts of the doctoral theses of S. Grundmann and F. Freund.

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

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