SWISS DENTAL JOURNAL SSO

Science and Clinical Topics

ISSN 2296-6498
swissdentaljournal.org

Scientific article

Changes in periapical status of root canal-treated teeth after head and neck IMRT: a retrospective study

Accepted: October 25, 2023
DOI: 10.61872/sdj-2024-09-01
2024, Vol. 134

Sina R Steiner[1], Fabio Saccardin[1], Thomas Connert[2], Andreas Filippi[1*]
[1] Department of Oral Surgery, University Center for Dental Medicine Basel (UZB), University of Basel, Switzerland
[2] Department of Periodontology, Endodontology and Cariology, University Center for Dental Medicine Basel (UZB), University of Basel, Switzerland

*Correspondence: Prof. Dr. med. dent. Andreas Filippi, Department of Oral Surgery, University Center for Dental Medicine Basel, Mattenstrasse 40, 4058 Basel
Telephone number: +41 61 267 26 10
email: andreas.filippi@unibas.ch

Keywords
Periapical status, Apical periodontitis, Intensity modulated radiotherapy, Osteoradionecrosis

Abstract

The objective of this retrospective study was to analyze the effect of the intensity modulated radiotherapy (IMRT) of the head and neck region on root canal-treated teeth and their periapical changes due to radiation. Patients undergoing IMRT of the head and neck region were evaluated. Different types of teeth (molars, premolars, incisors and canines) were compared. Panoramic and dental radiographs were used to assess the periapical region of root canal-treated teeth using the periapical index (PAI) before and after radiotherapy (RT) and put in relation to the radiation dose per tooth. Further parameters (patient-, therapy- and tooth-related factors) were included in this study. One hundred and twenty-four root canal-treated teeth (maxilla and mandible) of 51 patients were observed. A radiolucency in the periapical region was seen in 34.7% of the samples before IMRT and an increasing number of 46% after IMRT (p-value 0.092). Clinical or radiological signs of osteoradionecrosis could not be determined. The only statistically significant difference was detected in regions irradiated with less than 40 Gy (p-value 0.045). In regions irradiated with higher doses (>40 Gy), comparable pathologies increased in non-significant numbers. A statistically significant increase of periapical pathologies was detected in premolars of the maxilla. The observations reported here suggest that a high radiation dose during IMRT has no significant consequences on root canal-treated teeth. To compare the success of endodontic treatment before versus after IMRT, further research needs to be done.

Introduction

Osteoradionecrosis (ORN) is a serious long-term complication of radiotherapy (RT), which can occur in the course of oncological treatment in patients with a malignant tumor in the head and neck region. Traumatic events, such as surgery to the irradiated mandible and maxilla, are the main risk factors for the development of ORN. High radiation doses or tooth removal shortly before the start of intensity modulated radiotherapy (IMRT) may also promote ORN (LEE ET AL. 2009, GLANZMANN & GRÄTZ 1995). In the literature, the prevalence of ORN is reported between 0-23% (SCHUURHUIS ET AL. 2015) depending on the population under investigation. Clinically, ORN typically manifests itself as a dehiscence of the mucosa with chronically exposed and necrotic bone, which persists for a period of at least three months without evidence of tumor persistence, tumor recurrence, or metastasis (MARX 1983, THORN ET AL. 2000, CHRCANOVIC ET AL. 2010, CHRONOPOULOS ET AL. 2018). Radiologically, pathologies appear in the form of bone destruction, decreased bone density, irregular bone sclerosis, sequestration, and even pathological fractures (JERECZEK-FOSSA & ORECCHIA 2002). Increased risk for subsequent ORN exists already at a radiation dose of 40 Gy (MURRAY ET AL. 1980) and is most likely to occur within the first three years after RT (THORN ET AL. 2000). At a dose of more than 70 Gy spontaneous ORN also occurs frequently (GOLDWASSER ET AL. 2007, MORRISH ET AL. 1981, GLANZMANN & GRÄTZ 1995, BEUMER ET AL. 1983). ORN therapy includes sequestrectomy or debridement with local plastic soft tissue coverage, and in severe cases mandibulectomy or resection including microvascular reconstructive techniques for bone and soft tissue (CHANG ET AL. 2001, NOTANI ET AL. 2003, ALAM ET AL. 2009, DAI ET AL. 2015), which can severely affect the quality of life of affected patients (ROGERS ET AL. 2015).

To minimize the risk of ORN, risk adapted dental care is performed as a standard procedure prior planned RT according to national and international guidelines (BORNSTEIN ET AL. 2001B, STUDER ET AL. 2007, STUDER ET AL. 2011, KRÜGER ET AL. 2018, WHITE ET AL. 2019, SHAW ET AL. 2000, BEECH ET AL. 2014). However, the extent of tooth restauration or removal is controversially discussed in the literature (BEUMER ET AL. 1983, BEUMER ET AL. 1984, JANSMA ET AL. 1992, STUDER ET AL. 2011). In that context, modern radiation techniques, such as IMRT, have significantly reduced oral side effects, including ORN, due to the locally different and controllable radiation doses (SCHUURHUIS ET AL. 2015, BEN-DAVID ET AL. 2007, STUDER ET AL. 2006, JERECZEK-FOSSA & ORECCHIA 2002, STUDER ET AL. 2004). Therefore, extractions of asymptomatic teeth and new total dentures should be avoided prior to IMRT (STUDER ET AL. 2007). In particular, the preservation of prosthetically important abutment teeth, such as root canal-treated teeth, receives special attention after RT.

According to the authors knowledge, there is still little evidence on the prognosis and consequences of root canal-treated teeth with IMRT (HOMMEZ ET AL. 2012). Thus, the indication for leaving or removing root canal-treated teeth as part of the focal restoration prior to IMRT is also not yet based on sound scientific evidence.

The aim of this study was to find out whether root canal-treated teeth at high radiation dose have an increased risk of developing periapical pathology after RT compared to less irradiated root canal-treated teeth. Such findings are of great relevance in order to provide an evidence-based recommendation for the extent of focal restoration prior to planned RT.

Materials and methods

Sample selection

The present retrospective study had available data from patients of the Head and Neck Tumor Center of the University Hospital Basel (USB) who presented to the Clinic for Oral Surgery of the University Center for Dentistry Basel (UZB) as part of the risk adapted dental care prior to planned RT and were subsequently enrolled in the recall system. The study protocol was previously reviewed and approved by the local ethics committee (EKNZ Study-ID 2020-02234). Appropriate patient consents for further scientific use of the health-related data were available. All patients with root canal-treated teeth who had clinical and radiological documentation before IMRT until at least 12 months after RT and whose dose distributions were also known were included in the study. Patient-specific information (sex, age, medical history) was obtained from the medical records. Tumor- and therapy-related information such as tumor diagnosis and TNM-staging, as well as therapy procedures performed (surgery, adjuvant RT, radio-chemotherapy) were recorded as well.

The following were considered inclusion criteria:
- dental examination before IMRT performed in our clinic
- presence of panoramic radiograph (PR) or periapical radiograph (PAR) of the examined tooth before IMRT
- root canal-treated teeth that were not removed before or during IMRT (based on current guidelines or patient request)
- IMRT in the head and neck region
- documented radiation dose of the root canal-treated teeth (detailed irradiation plans)
- radiological follow-up at least 12 months after IMRT

The following were considered exclusion criteria:
- root canal-treated teeth, which had already been removed prior to IMRT
- further RT in the head and neck region (second tumor or tumor recurrence)
- incomplete documentation before or after RT
- observation period of less than one year
- presence of a documented refusal or missing declaration of consent for the further use of health-related data of the patient

Clinical and radiological examination

Since most of the patients were referral patients from regional dentists, a standard examination was performed at the UZB before and after IMRT and existing, current radiographs were considered and supplemented as necessary. Retrospectively, the clinical and radiological data before as well as after IMRT were analyzed in detail for this study by two operators (FS & SS). For this purpose, the following tooth-related factors were taken based on the available radiographs, i.e. PR or PAR:
- differentiation between adequate root filling (no voids and sufficient preparation length, no fractured instrument) and inadequate root canal filling (too short/extruded root filling or present voids in the root filling material or present fractured instrument)
- existing root apex resection
- type of restoration (unrestored, crown or filling, restoration including post)

- restoration condition
- periodontal condition (horizontal and vertical bone loss)

Clinical findings (percussion test, restoration condition, apical palpation) and periodontal condition (teeth with probing depth > 4mm with bleeding on probing, attachment loss >5mm, increased degree of mobility, probing of furcation) were documented for each patient.
Furthermore, the periapical pathosis was assessed by two independent operators (FS & SS) using the periapical index (PAI) (ORSTAVIK ET AL. 1986). The two observers have not been involved in the treatment of the patients. The scoring system was explained by an experienced endodontist (TC) by means of exemplary radiographs for calibration purposes. Afterwards the operators evaluated a catalogue of 100 radiographs on their own. This was repeated after one and two weeks. Agreement with the true scores as well as intra- and interrater agreement was assessed by calculating weighted kappa. Agreement was achieved by a value higher than 0.61.
The PAI scores 1 and 2 indicate healthy periapical conditions, PAI scores 3, 4 and 5 were associated with periapical pathology. Teeth with more than one root were categorized according to the root with the highest PAI score.
The subsequent determination of the PAI score of the teeth to be examined before and after IMRT was performed independently by the two operators (FS & SS) in a darkened room using the Digora radiographic software (Version 2.9.113.490, Soredex, Tuusala, Finland). In case of discrepancies, an endodontist (TC) was involved for the evaluation.

Radiation dose determination

The teeth were divided into three groups (anterior teeth, premolars and molars). These groups were differentiated for the maxilla and the mandible. With the help of detailed irradiation plans the radiation dose of the individual teeth could be determined. The teeth were divided into three groups according to their total dose: low radiation dose <40 Gy, medium radiation dose 40-50 Gy and high radiation dose >50 Gy. These categories were also seen in the study by BORNSTEIN ET AL. (2001B).

Statistical Analysis

Categorical variables were described by indicating the number and percentage in each group including the corresponding significant test chi-square.
PAI scores 1-2 and 3-5 were analysed pre and post IMRT by logistic regression analysis with a binomial data structure considering the repeated measure design of multiple teeth per subject. Nested regression designs were applied in order to calculate separate estimates for the given categories for IMRT or tooth groups. All regressions were additionally adjusted for age and sex. The resulting estimates were odds ratios (OR) with the corresponding 95% confidence interval (CI) and p-value. A p-value <0.05 was considered as significant (two-sided). Adjustment for multiple comparisons was omitted, because of the descriptive nature of the study. All analysis were performed with the statistical program R (Version 3.5.3, R Core Team, A language and environment for statistical computing, R Foundation for Statistical Computing, Vienna, Austria, 2018).

Results

Patient-specific data

From the 2002-2018 patient population there were a total of 51 patients with 124 root canal-treated teeth that were not extracted prior to IMRT in the head and neck region on the occasion of focal restoration and met the requirements for this study. Regarding the composition of the patient population 72.5% were male and 27.5% were female with a mean age of 67.9 years (min 49, max 90). 36 patients (70.6%) had other known pre-existing conditions or secondary diagnoses (including cardiovascular disease, metabolic disease, alcohol and/or nicotine abuse, mental illness, skin disease). No comorbidities were present in 15 patients (29.4%). 30 subjects (58.8%) had more than one root canal-treated tooth relevant to the study. 10 subjects (19.6%) had two teeth, 20 subjects (39.2%) even three to six root canal-treated teeth, which were included in the study.

Therapy-specific data

On average, the subjects were irradiated with a total dose of 63.9 Gy. Compared to the total dose, the radiation dose to the periapical regions that were examined was lower with an average of 38.7 Gy (min. 10 Gy, max. 73 Gy).
In addition to RT, 12 subjects (23.5%) also underwent chemotherapy. 34 patients (66.7%) underwent surgery with adjuvant RT.

Tooth-specific data

A total of 87 teeth in the maxilla and 37 teeth in the mandible were examined (Table 1). The teeth were subdivided according to their specific radiation dose (Table 2). The average observation period was 63.4 months (min. 12mts, max. 167mts). Other tooth-specific clinical and radiological parameters were classified as well (Table 3).

Table 1. Classification of the specimen subgroups according to their localization and tooth type (n=124)

	Maxilla Molars	Premolars	Anterior teeth	**Mandible** Molars	Premolars	Anterior teeth
n	10	38	39	5	19	13

Table 2. Classification of samples into their irradiation dose (n=124)

	<40 Gy	**40-50 Gy**	**>50 Gy**
Maxilla	35	40	12
Mandible	19	9	9

Table 3. Dental findings before and after IMRT (n=124)

	before IMRT n	%	**after IMRT (Follow-up)** n	%
Type of radiograph				
Periapical radiograph	68	54.8	85	68.5
Panoramic radiograph	56	45.2	39	31.5
Quality of root filling				
adequate	37	29.8	37	29.8
inadequate	87	70.2	87	70.2
Cllinical Symptoms (percussion, apical palpation)				
negative	122	98.4	120	96.8
positive	2	1.6	4	2.4
Type of restoration				
unrestored	2	1.6	5	4.1
crown or filling	57	46.0	50	40.3
including a post	65	52.4	69	55.6
Quality of restoration				
sufficient	116	93.5	104	83.9
insufficient	8	6.5	20	16.1
Periodontal situation				
healthy	54	43.5	37	29.8
questionable	70	56.5	87	70.2

Results of PAI score calibration

The calibration of the observers showed a Cohen's kappa for comparison of raters with true scores of 0.73 (FS) and 0.65 (SS). The intra-rater score of the three calibration runs was 0.81 (FS) and 0.84 (SS). The calibration led to an inter-rater agreement of 0.66 (FS vs. SS).

PAI before and after IMRT

The evaluation of the radiographs before IMRT showed that PAI score 1 and 2 (healthy) could be determined in 65.3% of the teeth (Table 4). Mild pathology was detected in 28.2% (PAI score 3). A pronounced pathology (PAI score 4 and 5) was detected in 6.4%. After IMRT only 54% of the teeth were classified as healthy by PAI. Accordingly, PAI score 3 was detected more frequently (33.9%). In 12.1% a pronounced pathology was evident.

PAI compared to radiation dose

The evaluation of the PAI score in relation to the radiation dose showed that a significant deterioration of the PAI score occurred only in the group of teeth irradiated with less than 40

Gy (Table 5). This group showed 2.2 times higher PAI scores after than before IMRT (p=0.045). In the other radiation groups (40-50 Gy and >50 Gy) higher PAI scores of 3-5 were also seen after IMRT with an increased tendency compared to the condition before IMRT. However, this was not statistically significant.
Only maxillary premolars showed a significant deterioration of the PAI score after IMRT (Table 6). There were more pathologies in this group (PAI scores 3-5) after IMRT. The other groups also showed increased PAI scores of 3-5 in the follow-up compared with the baseline situation before IMRT but without statistical significance.

Table 4. Distribution of PAI scores 1-5 before and after IMRT (n=124)

	before IMRT		**after IMRT**	
	n	**%**	**n**	**%**
PAI score 1	61	49.2	44	35.5
PAI score 2	20	16.1	23	18.5
PAI score 3	35	28.2	42	33.9
PAI score 4	5	4.0	8	6.5
PAI score 5	3	2.4	7	5.6

Table 5. Change of PAI scores before and after IMRT in relation to radiation dose

PAI: 3-5 vs 1-2	**Graykat**	**adj odds ratio**	**lower 95% CI**	**upper 95% CI**	**p value**
	<40 Gy	2.2	1.0	4.9	*0.045
	40-50 Gy	1.4	0.67	3.2	0.36
	>50 Gy	1.3	0.36	4.6	0.70

Note. Age and sex were included in the logistic regression models resulting in adjusted odds ratios..

Table 6. Change of PAI scores before and after IMRT in relation to tooth group

PAI: 3-5 vs 1-2	**Group**	**adj odds ratio**	**lower 95% CI**	**upper 95% CI**	**p value**
Maxilla	Anterior Teeth	1.1	0.46	2.8	0.79
	Premolars	2.9	1.2	7.3	*0.024
	Molars	1.6	0.28	8.7	0.62
Mandible	Anterior Teeth	1.5	0.29	7.9	0.63
	Premolars	1.6	0.27	10.1	0.60
	Molars	2.9	0.19	45.2	0.45

Note. Age and sex were included in the logistic regression models resulting in adjusted odds ratios.

Discussion

Tooth preservation or removal prior to IMRT

Xerostomia, as a result of destruction of salivary gland cells due to irradiation, leads to reduced salivatory clearance as well as decreased buffering capacity and alters the oral microbiota (BROWN ET AL. 1975, MARKS ET AL. 1981). Further complications of RT, such as mucositis or trismus lead to reduced oral hygiene (HERMANN ET AL. 1994, RIESENBECK ET AL. 1998). Due to these structural and physiological changes, dental damage after irradiation is increased, including rapidly progressing radiation caries (GRÖTZ ET AL. 1997, BORNSTEIN ET AL. 2001A). Therefore, it is possible for the pathology to end up in a pulpitis or apical periodontitis, which may lead to an infected ORN at a later stage (KIELBASSA ET AL. 2006) or to the removal of the irradiated tooth, which is associated with an increased risk of trauma induced ORN (BEUMER ET AL. 1984, REUTHER ET AL. 2003).

The aim of risk adapted dental care is to eliminate current and potential foci of infection to avoid future tooth extractions and reduce the risk of ORN in irradiated regions (NABIL & SAMMAN 2012). Because infected ORN is of dental origin in 64% of the cases (GRÖTZ ET AL. 1994), current recommendations regarding the treatment of dental foci prior to RT have been followed (BORNSTEIN ET AL. 2001B, JANSMA ET AL. 1992, STUDER ET AL. 2007, STUDER ET AL. 2011). This includes different procedures with varying invasiveness depending on the radiation dose of the individual tooth. Teeth with advanced periodontitis and profound caries, devitalized teeth and those with existing apical pathology should be extracted in high-risk areas (>50 Gy) prior radiation therapy. Furthermore, ORN is almost exclusively found in the mandible (BEUMER & BRADY 1978, PERRIER & MOELLER 1994). This can be explained by the centripetal monoarterial blood supply in the mandible through the inferior alveolar artery running in the alveolar canal. Due to the lack of vascular anastomoses, a markedly hypovascularized, hypoxic and hypocellular tissue forms as a result of irradiation, which is part of the causative complex of ORN (MARX 1983).

In this study, deterioration of PAI score after IMRT was seen in teeth in the low irradiation range (<40 Gy). The reason for this is speculative but could have to do with the individual treatment plans of the patients. Since the teeth were in the low-dose area, they were left in situ during focal restoration. Conversely, this would mean that a high radiation dose during IMRT has no significant effect on root canal-treated teeth and emerging periapical pathologies. Thus, inconspicuous root canal-treated teeth could be left in place during IMRT.

How firmly chemotherapy influences the risk of developing ORN is debated in the literature. GLANZMANN & GRÄTZ (1995) could not detect any influence while REUTHER ET AL. (2003) found an increased risk due to chemotherapy. KUBOTA ET AL. (2021) recognized the association of an increased risk of developing ORN with the use of concurrent chemotherapy as well as pre-RT mandibular surgery.

Tooth removal prior to RT should always be carefully evaluated as removable dentures should be worn as little as possible after radiation (FEBER 1996) and also to preserve the patient's quality of life. However, abutment teeth should preferably be preserved for a well-fitting removable prosthesis. Otherwise, missing abutment teeth could lead to pressure points, which would represent a risk factor for the development of ORN (RAGUSE ET AL. 2016, TOLJANIC & SAUNDERS 1984). In the case of caries with pulp involvement, root canal treatment (RCT) is preferable to tooth removal (BEECH ET AL. 2014).

Due to less risk of ORN in the maxilla there were less teeth extracted before IRMT compared to the mandible. Therefore, this study included more specimens in the maxilla. Likewise, the lowest irradiated category (<40 Gy) contains the most teeth, since ORN is hardly to be expected at this radiation dose and these teeth are not primarily removed before IMRT (MURRAY ET AL. 1980).
The advantages and disadvantages of tooth extraction before IMRT were carefully evaluated for each tooth. Explanations for remaining teeth with a PAI score of 3 before IMRT are as follows: The examined tooth is located in a region that is hardly irradiated during IMRT, important abutment tooth (e.g. root post caps for hybrid dentures), only few other remaining teeth left, clinically asymptomatic tooth with widened periodontal space or extruded root filling material (PAI score 3). Despite indications, there were subjects who refused tooth extraction as part of the focal restoration. For this reason, some teeth with pathological PAI scores of 3-5 and teeth with questionable prognosis were left in situ before IMRT.

Reliability of the radiographs

PARs were taken only when needed whilst PRs were part of dental diagnosis before IMRT. For the radiological evaluation of this study, PAR could be used in most cases. Nevertheless, especially before IMRT, there was a large proportion of 56 samples (45.2%) in which only a PR was available. In the follow-up after IMRT there were only 39 specimens without PAR (31.5%). RIDAO-SACIE ET AL. (2007) showed that the percentage of estimated pathologic apical lesions (PAI scores 3-5) was three times higher with PRs than with PARs. Thus, comparison of the periapical situation before and after IMRT is limited for some of the examined teeth. Therefore, the results should be taken with caution and the PAI values might tend to be somewhat higher if PR had been present in each case. HOMMEZ ET AL. (2012) also used PRs to evaluate PAI in irradiated patients to investigate the relationship between irradiation dose and the development of apical periodontitis after RT. The literature contains other studies that recognized a PR for periapical evaluation (MOLANDER ET A. 1993, ROHLIN ET AL. 1989, TAMMISALO ET AL. 1996). A further explanation for the significant increase in periapical pathologies in maxillary premolars in the low-irradiated (<40 Gy) samples of this study could be that PAR are less sensitive to detect periapical pathologies in molars or anterior teeth (MOLANDER B 1996).

Disbalance in the observation period and distribution of samples

There were intervals of between 12-167 months between the focal rehabilitation and the control after IMRT. Various sources indicate that the frequency of apical pathologies and thus increased PAI scores are related to the age of the patients (KIRKEVANG ET AL. 2012, RAZDAN ET AL. 2022). Accordingly, a longer time interval is also more likely to result in an increase in PAI score.
Likewise, the fact that patients participated with different numbers of specimens should be taken into account when evaluating the results. Thus, there was also a disbalance in the distribution of teeth among the subjects. While most of the subjects had only one root canal-treated tooth included in the study, there was also clustering in patients with up to six teeth examined. Personal- and therapy-related factors of the subjects investigated can lead to a bias in the evaluation.

RCT before versus after IMRT

Teeth that received RCT after RT instead of being removed beforehand have a worse success rate (40%) than non-irradiated teeth (SETO ET AL. 1985). However, no ORN was observed in these teeth. Despite persistence of the apical lesion or recurrence of pain, 85% of the root canal-treated teeth could be preserved. For comparison, the success rate of a primary RCT without irradiation is between 68 to 85% (NG ET AL. 2007). For this, only teeth with no radiolucent structure in the periapical bone one year after RCT were rated as a success. Since the subjects of this study are referral patients, it is not possible to provide more precise information on the time point at which RCT was performed prior to IMRT and therefore if the periapical lesions were still in a healing process.

Teeth with apical periodontitis have a worse success rate than teeth with radiologically inconspicuous apices (KOJIMA ET AL. 2004, CHUGAL ET AL. 2017). The quality of root fillings has been improved due to rotary instrumentation and modern techniques. An adequate root filling is an important factor for achieving a healthy periapical condition (CONNERT ET AL. 2019). In the literature the success rate of primary RCTs after RT is further discussed. MARKITZIU & HELING (1981) demonstrated success in only 2 of 11 RCTs of already irradiated teeth. LILLY ET AL. (1998) prescribed a success rate of 91% of RCTs after RT and MONTGOMERY (1977) showed success in six root canal-treated teeth in one patient.

In general, the comparison of the studies is difficult because the criteria for success of RCTs are not precisely specified in the literature and both, the recording technique and the preparation technique, have shown considerable evolution over the years.

Due to the above discussed structural and physiological changes, complications usually occur in irradiated patients which may indirectly lead to dental damage (BORNSTEIN ET AL. 2001A). Even already root canal-treated teeth are affected by this risk. Particularly low-quality classified root fillings can lead to infection recurrence. TABASSUM & KHAN (2016) identified the following factors that may be associated with endodontic failure: Intracanal persistent bacteria, inadequately cleaned and/or filled root canals, incompletely prepared root canals or extruded root filling material, coronal leakage, unprepared canals, iatrogenic factors, and instrumentation errors (perforation, fractures).

Clinically, endodontic failure presents with persistent apical periodontitis or persistent symptoms. However, the criteria for endodontic failure are not standardized in the literature, which is why an optimal means of comparing the different success rates is not completely possible.

Apical periodontitis is a microbiological infection of the root canal system (KAKEHASHI ET AL. 1965) and the radiological surrogate for it is periapical radiolucency (STRINDBERG 1956). Radiolucency is a sign of less periapical bone density as a result of an inflammatory reaction due to the bacterial infection of the root canal system. ORSTAVIK ET AL. (1986) provides a scoring system to evaluate this apical periodontitis radiologically.

The bone adaptation slows down after IMRT due to the limited reparative capacity of the jawbone, therefore the reduction of the radiographic radiolucency in periapical lesions is limited (KIELBASSA ET AL. 1995). Accordingly, a restitutio ad integrum is not to be expected. Furthermore, in regions with increased irradiation doses, inflammation of the jawbone occurs more frequently (HOMMEZ ET AL. 2012). Thus, it is obvious that lesions that were already radiologically recognizable prior to RT are either unchanged or progressive after IMRT.

In summary, the observations reported here suggest that a high radiation dose during IMRT had no significant effect on root canal-treated teeth and emerging periapical pathologies. However, to confirm this statement and to compare the success of root canal treatment before and after IMRT, further investigations need to be performed. Due to the cross-sectional study design, no statement can be made regarding the periapical healing process. The results of the present study should therefore be examined in the context of future prospective longitudinal cohort studies, which will provide more detailed information on the development process and healing of periapical lesions.
A standard recommendation for the treatment of root canal-treated teeth before IMRT cannot yet be given due to a lack of evidence.

Zusammenfassung

Einleitung

Ziel dieser retrospektiven Studie war es, die Auswirkungen der intensitätsmodulierten Strahlentherapie (IMRT) im Kopf- und Halsbereich auf wurzelkanalbehandelte Zähne und deren strahlenbedingten periapikalen Veränderungen zu analysieren. Dabei wurde untersucht, ob wurzelkanalbehandelte Zähne mit hoher Strahlendosis (>50 Gy) im Vergleich zu mit geringer Dosis bestrahlten wurzelkanalbehandelten Zähnen (<40 Gy) ein erhöhtes Risiko haben, nach einer Strahlentherapie eine periapikale Pathologie zu entwickeln. Solche Erkenntnisse sind von grosser klinischer Relevanz, um eine evidenzbasierte Empfehlung für das Ausmass der Fokussanierung vor einer geplanten Strahlentherapie im Kopf- und Halsbereich zu geben.

Material und Methoden

Es wurden radiologische Daten von Patienten der Klinik für Oralchirurgie am Universitären Zentrum für Zahnmedizin Basel (UZB) untersucht, die eine IMRT im Kopf- und Halsbereich bekommen haben. Ausserdem wurden verschiedene Zahntypen (Molaren, Prämolaren, Schneidezähne und Eckzähne) miteinander verglichen. Mehrere Panorama- und Zahnröntgenaufnahmen wurden verwendet, um den periapikalen Bereich von wurzelkanalbehandelten Zähnen anhand des periapikalen Index (PAI) vor und nach IMRT in Abhängigkeit von der Strahlendosis zu beurteilen. Weitere Parameter (patienten-, therapie- und zahnbezogene Faktoren) wurden in diese Studie miteinbezogen.

Resultate

Insgesamt wurden in dieser Studie 124 wurzelkanalbehandelte Zähne von 51 Patienten untersucht. Eine vorhandene Pathologie in der periapikalen Region wurde bei 34,7 % der Proben vor IMRT und bei 46 % nach IMRT festgestellt (p-Wert 0,092). Klinische oder radiologische Anzeichen einer Osteoradionekrose konnten nicht festgestellt werden. Der einzige statistisch signifikante Unterschied wurde in Regionen festgestellt, die mit weniger als 40 Gy bestrahlt wurden (p-Wert 0,045). Bei wurzelkanalbehandelten Zähnen, die mit höheren Dosen bestrahlt wurden (>40 Gy), nahmen periapikale Pathologien nach IRMT in nicht-signifikantem Ausmass zu. Ein statistisch signifikanter Anstieg der periapikalen Pathologien wurde bei den Prämolaren des Oberkiefers festgestellt.

Diskussion

Die hier gezeigten Beobachtungen deuten darauf hin, dass eine hohe Strahlendosis während der IMRT keine signifikanten Auswirkungen auf wurzelbehandelte Zähne und entstehende periapikale Pathologien hat. Somit könnte man bei der Fokussuche unauffällige wurzelkanalbehandelte Zähne belassen, was auch der Kaufähigkeit und Lebensqualität des Patienten entgegenkommen dürfte. Um diese Aussage zu bestätigen und den Erfolg einer Wurzelkanalbehandlung vor und nach IMRT zu vergleichen, müssen allerdings weitere Untersuchungen durchgeführt werden.
Eine Standardempfehlung für die Fokussanierung von wurzelkanalbehandelten Zähnen vor IMRT kann aufgrund mangelnder Evidenz noch nicht gegeben werden.

Résumé

Introduction

L'objectif de cette étude rétrospective est d'analyser les effets de la radiothérapie à modulation d'intensité (IMRT) dans la région de la tête et du cou sur les dents traitées par canal radiculaire et leurs modifications périapicales induites par l'irradiation. Il s'agit de déterminer si les dents traitées par canal radiculaire à forte dose de rayonnement (>50 Gy) présentent un risque accru de développer une pathologie périapicale après une radiothérapie par rapport aux dents traitées par canal radiculaire à faible dose de rayonnement (<40 Gy). De tels résultats sont cliniquement pertinent pour donner une recommandation fondée sur des preuves concernant l'étendue du traitement dentaire avant une radiothérapie planifiée dans la région de la tête et du cou.

Matériel et méthodes

Les données radiologiques de patients de la clinique de chirurgie orale du centre universitaire de médecine dentaire de Bâle (UZB), qui ont subi une IMRT dans la région de la tête et du cou, ont été examinées. Différents types de dents (molaires, prémolaires, incisives et canines) ont été comparés. Plusieurs radiographies panoramiques et dentaires ont été utilisées pour évaluer la zone périapicale des dents traitées par canal radiculaire sur la base de l'indice périapical (PAI) avant et après IMRT en fonction de la dose de rayonnement. D'autres paramètres (facteurs liés au patient, au traitement et à la dent) ont été inclus dans cette étude.

Résultats

Au total, 124 dents traitées par canal radiculaire provenant de 51 patients ont été examinées dans le cadre de cette étude. Une pathologie existante dans la région périapicale a été observée dans 34,7 % des échantillons avant IMRT et dans 46 % après IMRT (p-value 0,092). Aucun signe clinique ou radiologique d'ostéoradionécrose n'a pas été constaté. La seule différence statistiquement significative a été observée à moins de 40 Gy (p-value 0,045). Pour les dents traitées par canal radiculaire et irradiées à des doses plus élevées (>40 Gy), les pathologies périapicales ont augmenté de manière non significative après IMRT. Une augmentation statistiquement significative des pathologies périapicales a été constatée sur les prémolaires de la mâchoire supérieure.

Discussion

Les observations présentées ici indiquent qu'une dose élevée de rayonnement pendant l'IMRT n'a pas d'effet significatif sur les dents traitées par canal radiculaire et les pathologies périapicales qui en résultent. Il serait donc possible de laisser des dents traitées par canal radiculaire lors de l'IMRT, ce qui devrait également être favorable à la capacité de mastication et à la qualité de vie du patient. Pour confirmer cette affirmation et comparer le succès d'un traitement de canal radiculaire avant et après IMRT, d'autres études doivent toutefois être menées. En raison du manque de preuves, il n'est pas encore possible de donner une recommandation standard pour le traitement des dents traitées par canal radiculaire avant l'IMRT.

References

ALAM D S, NUARA M, CHRISTIAN J: Analysis of outcomes of vascularized flap reconstruction in patients with advanced mandibular osteoradionecrosis. Otolaryngol Head Neck Surg 141: 196-201 (2009

BEECH N, ROBINSON S, PORCEDDU S, BATSTONE M: Dental management of patients irradiated for head and neck cancer. Aust Dent J 59: 20-28 (2014)

BEN-DAVID M A, DIAMANTE M, RADAWSKI J D, VINEBERG K A, STROUP C, MURDOCH-KINCH C A, ZWETCHKENBAUM S R, EISBRUCH A: Lack of osteoradionecrosis of the mandible after intensity-modulated radiotherapy for head and neck cancer: likely contributions of both dental care and improved dose distributions. Int J Radiat Oncol Biol Phys 68: 396-402 (2007)

BEUMER J 3RD, BRADY F A: Dental management of the irradiated patient. Int J Oral Surg 7: 208-220 (1978)

BEUMER J 3RD HARRISON R, SANDERS B, KURRASCH M: Preradiation dental extractions and the incidence of bone necrosis. Head Neck Surg 5: 514-521 (1983)

BEUMER J, HARRISON R, SANDERS B, KURRASCH M: Osteoradionecrosis: predisposing factors and outcomes of therapy. Head Neck Surg 6: 819-827 (1984)

BORNSTEIN M, FILIPPI A, BUSER D: Früh- und Spätfolgen im intraoralen Bereich nach Strahlentherapie. Schweiz Monatsschr Zahnmed 111: 61-73 (2001a)

BORNSTEIN M, BUSER D, FILIPPI A: Konzepte zur Prophylaxe und Therapie strahlungsbedingter Nebenwirkungen. Schweiz Monatsschr Zahnmed 111: 962-977 (2001b)

BROWN L R, DREIZEN S, HANDLER S, JOHNSTON D A: Effect of radiation-induced xerostomia on human oral microflora. J Dent Res 54: 740-750 (1975)

CHANG D W, OH H K, ROBB G L, MILLER M J: Management of advanced mandibular osteoradionecrosis with free flap reconstruction. Head Neck 23: 830-835 (2001)

CHRCANOVIC B R, REHER P, SOUSA A A, HARRIS M: Osteoradionecrosis of the jaws--a current overview--part 1: Physiopathology and risk and predisposing factors. Oral Maxillofac Surg 14: 3-16 (2010)

CHRONOPOULOS A, ZARRA T, EHRENFELD M, OTTO S: Osteoradionecrosis of the jaws: definition, epidemiology, staging and clinical and radiological findings. A concise review. Int Dent J 68: 22-30 (2018)

CHUGAL N, MALLYA S M, KAHLER B, LIN L M: Endodontic Treatment Outcomes. Dent Clin North Am 61: 59-80 (2017)

CONNERT T, TRUCKENMÜLLER M, ELAYOUTI A, EGGMANN F, KRASTL G, LÖST C, WEIGER R: Changes in periapical status, quality of root fillings and estimated endodontic treatment need in a similar urban German population 20 years later. Clin Oral Investig 23: 1373-1382 (2019)

DAI T, TIAN Z, WANG Z, QIU W, ZHANG Z, HE Y: Surgical management of osteoradionecrosis of the jaws. J Craniofac Surg 26: 175-179 (2015)

FEBER T: Management of mucositis in oral irradiation. Clin Oncol (R Coll Radiol) 8: 106-111 (1996)

GLANZMANN C, GRÄTZ K W: Radionecrosis of the mandibula: a retrospective analysis of the incidence and risk factors. Radiother Oncol 36: 94-100 (1995)

GOLDWASER B R, CHUANG S K, KABAN L B, AUGUST M: Risk factor assessment for the development of osteoradionecrosis. J Oral Maxillofac Surg 65: 2311-2316 (2007)

GRÖTZ K A, DIWO T, HENRICH G, WAGNER W: Wundheilungsstörungen nach chirurgischer Zahnsanierung prä und post radiationem bei malignen Kopf-Hals-Tumoren. Dtsch Zahnärztl 49: 1036-1039 (1994)

GRÖTZ K A, DUSCHNER H, WAGNER W: Konfokale Laser-Scanning-Mikroskopie (CLSM): Histotomographie veränderter Zahnhartgewebe bei pathologischer Mundhöhlenökologie. Mund Kiefer GesichtsChir 1: 39-43 (1997)

HERMANN J, JAKUBEK A, TROTT K R: The importance of the timing of a gap in radiotherapy of squamous cell carcinomas of the head and neck. Strahlenther Onkol 170: 545-549 (1994)

HOMMEZ G M, DE MEERLEER G O, DE NEVE W J, DE MOOR R J: Effect of radiation dose on the prevalence of apical periodontitis--a dosimetric analysis. Clin Oral Investig 16: 1543-1547 (2012)

JANSMA J, VISSINK A, SPIJKERVET F K, ROODENBURG J L, PANDERS A K, VERMEY A, SZABÓ B G, GRAVENMADE E J: Protocol for the prevention and treatment of oral sequelae resulting from head and neck radiation therapy. Cancer 70: 2171-2180 (1992)

JERECZEK-FOSSA B A, ORECCHIA R: Radiotherapy-induced mandibular bone complications. Cancer Treat Rev 28: 65-74 (2002)

KAKEHASHI S, STANLEY H R, FITZGERALD R J: The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. Oral Surg Oral Med Oral Pathol 20: 340-349 (1965)

KIELBASSA A M, ATTIN T, SCHALLER H G, HELLWIG E: Endodontic therapy in a postirradiated child: review of the literature and report of a case. Quintessence Int 26: 405-411 (1995)

KIELBASSA A M, HINKELBEIN W, HELLWIG E, MEYER-LÜCKEL H: Radiation-related damage to dentition. Lancet Oncol 7: 326-335 (2006)

KIRKEVANG L L, VAETH M, WENZEL A: Ten-year follow-up observations of periapical and endodontic status in a Danish population. Int Endod J 45: 829-839 (2012)

KOJIMA K, INAMOTO K, NAGAMATSU K, HARA A, NAKATA K, MORITA I, NAKAGAKI H, NAKAMURA H: Success rate of endodontic treatment of teeth with vital and nonvital pulps. A meta-analysis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 97: 95-99 (2004)

KRÜGER M, HAUTMANN M, BARTELLA A, AL-NAWAS B, GRÖTZ K A: Langfassung der S2k-Leitlinie «Infizierte Osteoradionekrose (IORN) der Kiefer». AWMF Online. AWMF-Registernummer: 007/046. https://www.awmf.org/uploads/tx_szleitlinien/007-046l_S2k_Infizierte-Osteoradionekrose-der-Kiefer-IORN_2018-02.pdf (letzter Aufruf 06.07.2023).

KUBOTA H, MIYAWAKI D, MUKUMOTO N, ISHIHARA T, MATSUMURA M, HASEGAWA T, AKASHI M, KIYOTA N, SHINOMIYA H, TESHIMA M, NIBU K I, SASAKI R: Risk factors for osteoradionecrosis of the jaw in patients with head and neck squamous cell carcinoma. Radiat Oncol 16: 1-11 (2021)

LEE I J, KOOM W S, LEE C G, KIM Y B, YOO S W, KEUM K C, KIM G E, CHOI E C, CHA I H: Risk factors and dose-effect relationship for mandibular osteoradionecrosis in oral and oropharyngeal cancer patients. Int J Radiat Oncol Biol Phys 75: 1084-1091 (2009)

LILLY J P, COX D, ARCURI M, KRELL K V: An evaluation of root canal treatment in patients who have received irradiation to the mandible and maxilla. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 86: 224-226 (1998)

MARKITZIU A, HELING I: Endodontic treatment of patients who have undergone irradiation of the head and neck. A longitudinal follow-up of eleven endodontically treated teeth. Oral Surg Oral Med Oral Pathol 52: 294-298 (1981)

MARKS J E, DAVIS C C, GOTTSMAN V L, PURDY J E, LEE F: The effects of radiation of parotid salivary function. Int J Radiat Oncol Biol Phys 7: 1013-1019 (1981)

MARX R E: Osteoradionecrosis: a new concept of its pathophysiology. J Oral Maxillofac Surg 41: 283-288 (1983)

MOLANDER B, AHLQWIST M, GRÖNDAHL H G, HOLLENDER L: Comparison of panoramic and intraoral radiography for the diagnosis of caries and periapical pathology. Dentomaxillofac Radiol 22: 28-32 (1993)

MOLANDER B: Panoramic radiography in dental diagnostics. Swed Dent J Suppl 119: 1-26 (1996)

MONTGOMERY S: Endodontic complications in an irradiated patient. J Endod 3: 277-279 (1977)

MORRISH R B JR, CHAN E, SILVERMAN S JR, MEYER J, FU K K, GREENSPAN D: Osteonecrosis in patients irradiated for head and neck carcinoma. Cancer 47: 1980-1983 (1981)

MURRAY C G, HERSON J, DALY T E, ZIMMERMAN S: Radiation necrosis of the mandible: a 10 year study. Part I. Factors influencing the onset of necrosis. Int J Radiat Oncol Biol Phys 6: 543-548 (1980)

NABIL S, SAMMAN N: Risk factors for osteoradionecrosis after head and neck radiation: a systematic review. Oral Surg Oral Med Oral Pathol Oral Radiol 113: 54-69 (2012)

NG Y L, MANN V, RAHBARAN S, LEWSEY J, GULABIVALA K: Outcome of primary root canal treatment: systematic review of the literature - part 1. Effects of study characteristics on probability of success. Int Endod J 40: 921-939 (2007)

NOTANI K, YAMAZAKI Y, KITADA H, SAKAKIBARA N, FUKUDA H, OMORI K, NAKAMURA M: Management of mandibular osteoradionecrosis corresponding to the severity of osteoradionecrosis and the method of radiotherapy. Head Neck 25: 181-186 (2003)

ORSTAVIK D, KEREKES K, ERIKSEN H M: The periapical index: a scoring system for radiographic assessment of apical periodontitis. Endod Dent Traumatol 2: 20-34 (1986)

PERRIER M, MOELLER P: L'ostéoradionécrose. Une revue de la littérature. Schweiz Monatssschr Zahnmed 104: 271-277 (1994)

RAGUSE J D, HOSSAMO J, TINHOFER I, HOFFMEISTER B, BUDACH V, JAMIL B, JÖHRENS K, THIEME N, DOLL C, NAHLES S, HARTWIG S T, STROMBERGER C: Patient and treatment-related risk factors for osteoradionecrosis of the jaw in patients with head and neck cancer. Oral Surg Oral Med Oral Pathol Oral Radiol 121: 215-221 (2016)

RAZDAN A, JUNGNICKEL L, SCHROPP L, VAETH M, KIRKEVANG L L: Trends of endodontic and periapical status in adult Danish populations from 1997 to 2009: A repeated cross-sectional study. Int Endod J 55: 164-176 (2022)

REUTHER T, SCHUSTER T, MENDE U, KÜBLER A: Osteoradionecrosis of the jaws as a side effect of radiotherapy of head and neck tumour patients--a report of a thirty year retrospective review. Int J Oral Maxillofac Surg 32: 289-295 (2003)

RIDAO-SACIE C, SEGURA-EGEA J J, FERNÁNDEZ-PALACÍN A, BULLÓN-FERNÁNDEZ P, RÍOS-SANTOS J V: Radiological assessment of periapical status using the periapical index: comparison of periapical radiography and digital panoramic radiography. Int Endod J 40: 433-440 (2007)

RIESENBECK D, DÖRR W, FEYERABEND T, FIETKAU R, HENNE K, RICHTER E, SCHENDERA A: Photographic documentation of acute radiation-induced side effects of the oral mucosa. Strahlenther Onkol 174: 40-43 (1998)

ROGERS S N, D'SOUZA J J, LOWE D, KANATAS A: Longitudinal evaluation of health-related quality of life after osteoradionecrosis of the mandible. Br J Oral Maxillofac Surg 53: 854-857 (2015)

ROHLIN M, AKESSON L, HAKANSSON J, HAKANSSON H, NASSTROM K: Comparison between panoramic and periapical radiography in the diagnosis of periodontal bone loss. Dentomaxillofac Radiol 18: 72-76 (1989)

SCHUURHUIS J M, STOKMAN M A, WITJES M J, DIJKSTRA P U, VISSINK A, SPIJKERVET F K: Evidence supporting pre-radiation elimination of oral foci of infection in head and neck cancer patients to prevent oral sequelae. A systematic review. Oral Oncol 51: 212-220 (2015)

SETO B G, BEUMER J 3RD, KAGAWA T, KLOKKEVOLD P, WOLINSKY L: Analysis of endodontic therapy in patients irradiated for head and neck cancer. Oral Surg Oral Med Oral Pathol 60: 540-545 (1985)

SHAW M J, KUMAR N D, DUGGAL M, FISKE J, LEWIS D A, KINSELLA T, NISBET T: Oral management of patients following oncology treatment: literature review. Br J Oral Maxillofac Surg 38: 519-524 (2000)

STRINDBERG L Z: The dependence of the results of pulp therapy on certain factors - an analytic study based on radiographic and clinical follow-up examinations. Acta Odontol Scand 14: 1-175 (1956)

STUDER G, GRÄTZ K W, GLANZMANN C: Osteoradionecrosis of the mandibula in patients treated with different fractionations. Strahlenther Onkol 180: 233-240 (2004)

STUDER G, STUDER S P, ZWAHLEN R A, HUGUENIN P, GRÄTZ K W, LÜTOLF U M, GLANZMANN C: Osteoradionecrosis of the mandible: minimized risk profile following intensity-modulated radiation therapy (IMRT). Strahlenther Onkol 182: 283-288 (2006)

STUDER G, GLANZMANN C, STUDER S P, GRÄTZ K W, LÜTOLF U M, ZWAHLEN R A: UniversitätsSpital Zürich. Empfehlung für die Zahnsanierung vor intensitäts-modulierter Radiotherapie (IMRT). UniversitätsSpital Zürich (USZ)-Richtlinien-Anpassung. Schweiz Monatsschr Zahnmed 117: 637-647 (2007)

STUDER G, GLANZMANN C, STUDER S P, GRÄTZ K W, BREDELL M, LOCHER M, LÜTOLF U M, ZWAHLEN R A: Risk-adapted dental care prior to intensity-modulated radiotherapy (IMRT). Schweiz Monatsschr Zahnmed 121: 216-229 (2011)

TABASSUM S, KHAN F R: Failure of endodontic treatment: The usual suspects. Eur J Dent 10: 144-147 (2016)

TAMMISALO T, LUOSTARINEN T, VÄHÄTALO K, NEVA M: Detailed tomography of periapical and periodontal lesions. Diagnostic accuracy compared with periapical radiography. Dentomaxillofac Radiol 25: 89-96 (1996)

THORN J J, HANSEN H S, SPECHT L, BASTHOLT L: Osteoradionecrosis of the jaws: clinical characteristics and relation to the field of irradiation. J Oral Maxillofac Surg 58: 1088-1093 (2000)

TOLJANIC J A, SAUNDERS V W JR: Radiation therapy and management of the irradiated patient. J Prosthet Dent 52: 852-858 (1984)

WHITE J M, PANCHAL N H, WEHLER C J, BESTGEN S C, COLÓN J E, DESAI H G, HOGUE C M, MARIANNE JURASIC M, MARITIM B C, ORTEGA A P, SMITH G M, TAYLOR J Y, GIBSON G: Department of Veterans Affairs Consensus: Preradiation dental treatment guidelines for patients with head and neck cancer. Head Neck 41: 1153-1160 (2019)