

Alessandro Marcelo Pelloso

**Influência da radioterapia
na estrutura intrarradicular e na condição pulpar
de pacientes pós radioterapia
em região de cabeça e pescoço**

*Influence of radiotherapy on the intraradicular structure and
pulp condition of patients after radiotherapy
in the head and neck region*

Tese apresentada à Faculdade de Odontologia
da Universidade Federal de Uberlândia,
para obtenção do Título de Doutor em Odontologia
na Área de Clínica Odontológica Integrada.

Uberlândia, 2024

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Orientadora: Profa. Dra. Veridiana Resende Novais Simamoto

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Uberlândia, 2024



UNIVERSIDADE FEDERAL DE UBERLÂNDIA

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Iniciando os trabalhos o(a) presidente da mesa, Dr(a). Veridiana Resende Novais Simamoto, apresentou a Comissão Examinadora e o candidato(a), agradeceu a presença do público, e concedeu ao Discente a palavra para a exposição do seu trabalho. A duração da apresentação do Discente e o tempo de arguição e resposta foram conforme as normas do Programa.

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“As pessoas mais importantes não são aquelas que tem a cabeça cheia de conhecimento... são aquelas que têm o coração cheio de amor, as orelhas prontas para escutar e as mãos prontas para ajudar.”

Um sábio...

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RESUMO

RESUMO

A radioterapia é o tratamento mais comum para neoplasias malignas em região de cabeça e pescoço, destruindo células neoplásicas por meio da modificação de suas estruturas moleculares. Entretanto, também afeta tecidos saudáveis no campo de irradiação, causando efeitos colaterais como xerostomia, mucosite, disfagia, disgeusia e cárie relacionada a radiação. Coroas dentárias extensamente destruídas, com indicação para exodontia e instalação de implante e prótese, são desafiadoras em pacientes irradiados devido ao risco de osteorradionecrose. O tratamento convencional é, portanto, contraindicado. Como alternativa, a preservação das raízes irradiadas pode ser realizada com retentores intrarradiculares de fibra de vidro, cimentados no canal radicular e coroas reconstruídas com resina composta, devolvendo função, estética e qualidade de vida ao paciente. Para entender os efeitos da radiação ionizante na dentina intrarradicular foi realizado um estudo laboratorial in vitro analisando a composição química e a microdureza da dentina intrarradicular de dentes incisivos inferiores extraídos de pacientes irradiados em cabeça e pescoço. Concluiu-se que a radiação alterou a composição química e a dureza da dentina, especialmente nos terços cervical e médio. O segundo objetivo foi um estudo observacional transversal de série de casos, em pacientes pós-irradiados com câncer em cabeça e pescoço, com pinos de fibra de vidro cimentados e reconstruídos diretamente com resina composta. Avaliou-se a descimentação do pino de fibra de vidro e a sobrevivência das coroas reconstruídas usando os critérios da FDI (World Dental Federation), por meio de avaliações clínicas e radiográficas. As reconstruções, realizadas entre novembro de 2019 e outubro de 2023, foram avaliadas em maio/abril de 2024. Não houve descimentação e todas as restaurações foram classificadas como satisfatória ou suficientes pelos critérios da FDI. O diagnóstico preciso da condição pulpar é crucial no tratamento odontológico. A radioterapia

pode alterar a resposta ao teste de vitalidade pulpar, levando a diagnósticos incorretos. Compreender os efeitos da radiação na condição pulpar pode prevenir erros de diagnóstico e tratamentos endodônticos desnecessários. Desta forma, o terceiro estudo foi um relato de caso verificando a condição pulpar, por meio do teste térmico frio, em pacientes tratados com radioterapia, avaliados aos 6 e 12 meses pós-tratamento. Constatou-se que a radiação modificou temporariamente a condição pulpar e a resposta ao teste de vitalidade pulpar ao frio. Seis meses após a radioterapia, os dentes apresentaram resposta negativa ao teste, mas, após 12 meses, alguns dentes apresentaram retorno da resposta de vitalidade pulpar.

Palavras-chave: canal radicular; câncer de cabeça e pescoço; radioterapia.

Abstract

ABSTRACT

Radiotherapy is the most common treatment for malignant neoplasms in the head and neck region, destroying neoplastic cells by modifying their molecular structures. However, it also affects healthy tissues in the irradiation field, causing side effects such as xerostomia, mucositis, dysphagia, dysgeusia and radiation-related caries. Extensively destroyed dental crowns, with indication for extraction and installation of implants and prostheses are challenging in irradiated patients due to the risk of osteoradionecrosis. Conventional treatment is therefore contraindicated. Alternatively, preservation of irradiated roots can be performed with intraradicular fiberglass retainers, cemented in the root canal and crowns reconstructed with composite resin, restoring function, aesthetics and quality of life to the patient. To understand the effects of ionizing radiation on intraradicular dentin, an in vitro laboratory study was carried out analyzing the chemical composition and microhardness of intraradicular dentin from lower incisor teeth extracted from patients irradiated in the head and neck. It was concluded that radiation altered the chemical composition and hardness of intraradicular dentin, especially in the cervical and middle thirds. The second objective was a cross-sectional observational study of a case series, in post-irradiated patients with head and neck cancer, with fiberglass posts cemented and reconstructed directly with composite resin. The decementation of the fiberglass post and the survival of the reconstructed crowns were evaluated using the FDI (World Dental Federation) criteria, through clinical and radiographic evaluations. The reconstructions carried out between November 2019 and October 2023, were evaluated in March/April 2024. There was no decementation and all restorations were classified as satisfactory or sufficient according to the FDI criteria. Accurate diagnosis of pulp condition is crucial in dental treatment. Radiotherapy can alter the response to the pulp vitality test, leading to incorrect diagnoses. Understanding the effects of radiation on pulp condition can prevent misdiagnosis and unnecessary endodontic treatments. Thus, the third study was a case report verifying the pulp condition, through the cold thermal test, in patients treated with radiotherapy, evaluated at 6 and 12 months post-treatment. It

was found that radiation temporarily modified the pulp condition and the response to the cold pulp vitality test. Six months after radiotherapy, the teeth showed a negative response to the test, but, after 12 months, some teeth showed a return of the pulp vitality response.

Keywords: head and neck cancer; radiotherapy; root canal.

INTRODUÇÃO E REFERENCIAL TEÓRICO

1. INTRODUÇÃO E REFERENCIAL TEÓRICO

O tratamento de neoplasias malignas na região de cabeça e pescoço geralmente utiliza radioterapia devido ao crescimento tecidual da doença e à dificuldade de remoção cirúrgica próxima a estruturas nobres [1]. Radicais livres gerados pela ionização de moléculas de água, como oxigênio e peróxido de hidrogênio, causam danos teciduais [2]. A radioterapia também altera tecidos saudáveis no campo de irradiação. Um dos efeitos colaterais amplamente estudados refere-se a alterações em estruturas dentárias irradiadas, principalmente no esmalte e dentina na região coronal [3, 4, 5, 6, 7, 8 e 9]. Poucos estudos analisaram o efeito da radioterapia na dentina radicular [10, 11, 12 e 13].

Coroas extensamente destruídas têm como primeira opção de tratamento a exodontia e a instalação de implantes e próteses. Para pacientes irradiados, essa conduta é problemática devido ao risco de osteorradionecrose no local da extração causada pela radiação ionizante [14 e 15]. Uma alternativa para preservar as raízes irradiadas envolve o uso de retentores intrarradiculares de fibra de vidro cimentados no canal radicular e coroas reconstruídas com resina composta, devolvendo função, estética e qualidade de vida ao paciente. No entanto, a provável alteração da dentina intrarradicular pode ser fator comprometedor da adesão do cimento resinoso à dentina radicular irradiada [10 e 11], comprometendo a adesão dos pinos de fibra de vidro nos canais radiculares [13 e 16]. A investigação nesse campo é escassa e necessária para possibilitar a reabilitação oral em pacientes com câncer de cabeça e pescoço após radioterapia.

Compreender o impacto da radioterapia na adesão de pinos de fibra de vidro à dentina intrarradicular em pacientes com câncer de cabeça e pescoço é crucial para otimizar a reabilitação dentária. A análise da dentina intrarradicular e alterações na composição orgânica e inorgânica através de estudo por análise química e estruturais poderiam elucidar alterações que justifiquem a adesão comprometida em dentes irradiados, uma vez que cimentos adesivos são comumente utilizados em dentes com extensa destruição coronária [13 e 16]. Apesar dos avanços nas técnicas adesivas, o sucesso da cimentação de pinos de fibra de vidro em dentes irradiados permanece incerto. Um estudo clínico avaliando a longevidade de dentes tratados endodonticamente e cimentados com pino de fibra de vidro e reconstruídos com resina composta em pacientes pós radioterapia,

respondendo se as alterações induzidas pela radiação na estrutura da dentina poderiam comprometer a capacidade de adesão dos pinos de fibra de vidro e uma avaliação criteriosa das coroas restauradas justificando sua performance, seriam bastante relevantes ao problema abordado.

O diagnóstico preciso da condição pulpar é essencial para o tratamento odontológico. A radioterapia pode alterar a resposta ao teste de vitalidade pulpar, levando a diagnósticos incorretos [18]. Compreender os efeitos da radiação ionizante na condição pulpar pode ajudar a prevenir erros de diagnóstico e tratamentos endodônticos desnecessários [19].

Portanto, esta tese foi dividida em três objetivos específicos e complementares, visando a compreensão sobre o tema acima contextualizado. O primeiro objetivo foi analisar a composição química e a microdureza da dentina intrarradicular de dentes extraídos de pacientes irradiados na região de cabeça e pescoço, divididos em três terços da raiz. O segundo objetivo foi um estudo observacional transversal de série de casos, com análise da descolagem do pino de fibra de vidro do canal radicular e a retenção da restauração, utilizando critérios da FDI (World Dental Federation) [17], juntamente com avaliações clínicas, radiográficas, tomográficas e fotográficas intra e extra-orais. E o terceiro objetivo foi um relato de caso para verificar a condição pulpar, por meio do teste térmico frio, da vitalidade pulpar, em paciente com câncer na região de cabeça e pescoço tratado com radioterapia e avaliado aos 6 e 12 meses pós-tratamento.

As hipóteses geradas são: 1. A radiação ionizante não altera a composição química e mecânica da dentina intrarradicular, independentemente do terço radicular; 2. A radiação ionizante não altera a qualidade da cimentação de pino de fibra de vidro em raízes de pacientes pós radioterapia em região de cabeça e pescoço e 3. A radiação ionizante não altera a resposta ao teste de vitalidade pulpar em raízes de pacientes pós radioterapia em região de cabeça e pescoço.

Capítulos

2.1. CAPÍTULO 1, ARTIGO 1

**RADIOTERAPIA NA REGIÃO DA CABEÇA E PESCOÇO INFLUENCIA AS
PROPRIEDADES QUÍMICAS E MECÂNICAS DA DENTINA INTRARADICULAR**

**RADIOTHERAPY IN THE HEAD AND NECK REGION INFLUENCES THE
CHEMICAL AND MECHANICAL PROPERTIES OF INTRARADICULAR DENTIN**

Artigo publicado no periódico Archives of Oral Biology

2.2. CAPÍTULO 2, ARTIGO 2

AVALIAÇÃO CLÍNICA E RADIOGRÁFICA DE DENTES TRATADOS ENDODONTICAMENTE, CIMENTADOS COM PINO DE FIBRA DE VIDRO E RECONSTRUÍDO DIRETAMENTE COM RESINA COMPOSTA EM PACIENTES COM CÂNCER DE CABEÇA E PESCOÇO: UM ESTUDO DE SÉRIES DE CASO

CLINICAL AND RADIOGRAPHIC EVALUATION OF ENDODONTIC TREATED TEETH, CEMENTED WITH FIBERGLASS POST AND RECONSTRUCTED DIRECTLY WITH COMPOSITE RESIN IN PATIENTS WITH HEAD AND NECK CANCER: A CASE SERIES STUDY

Artigo a ser submetido para publicação no periódico Clinical Oral Investigations

CLINICAL AND RADIOGRAPHIC EVALUATION OF ENDODONTIC TREATED TEETH, CEMENTED WITH FIBERGLASS POST AND RECONSTRUCTED DIRECTLY WITH COMPOSITE RESIN IN PATIENTS WITH HEAD AND NECK CANCER: A CASE SERIES STUDY

Alessandro Marcelo Pelloso, Carlos José Soares, Guilherme José Pimentel Lopes de Oliveira, Veridiana Resende Novais

Abstract

Purpose: To investigate the debonding of fiberglass posts in teeth of patients with head and neck cancer treated with radiotherapy through clinical and radiographic evaluation and to evaluate the survival of the indirect resin composite crowns using FDI (World Dental Federation) criteria.

Methods: Four patients, involving six fiberglass posts cemented with self-adhesive resin cement and restored using adhesively cemented direct resin composite crowns between November 2019 and November 2023, were monitored and evaluated between March and April 2024 through sociodemographic profile extracted from medical records, clinical examination and FDI (World Dental Federation) criteria for reconstructed crowns, panoramic and periapical radiographs, tomography, and intra and extraoral photography.

Results: The radiotherapy dosage ranged from 44 to 72 Gy. No failures such as debonding of the fiberglass post, root fracture and pain were observed. One patient suffered a fracture of the crown and a small part of the fiberglass post after two years of follow-up. Only one tooth presented a chipped fracture at buccal surface. All teeth showed excellent or good marginal adaptation and contour shape, with good proximal contact points. Three teeth showed marginal caries lesions with slight softened dentin. Most restorations maintained excellent gloss and surface texture. The marginal color changed slightly in one case and remained unchanged in the others. The color of the restoration remained unchanged.

Conclusion: No debonding of the fiberglass post during the clinical and radiographic follow-up period was found. Direct resin composite crown restorations had good performance, restoring function and aesthetics, improving the patient's quality of life. The marginal caries lesions remain the challenge for head and neck cancer patient treated with radiotherapy.

Clinical relevance: Fiberglass post and direct resin composite crown restoration can be an alternative to rehabilitate the teeth with severely destroyed crowns in irradiated patients with head and neck cancer.

Keywords: case series; direct resin composite crown; fiberglass post; head and neck neoplasms; radiation-related caries; radiotherapy.

Introduction

The increasing on the occurrence of head and neck cancer presents significant challenges due to its impact on patients' quality of life and the complex of treatment [1]. Malignancies of these cancers include the oral cavity, pharynx, larynx, and salivary glands, with squamous cell carcinoma being the most common subtype [2]. Treatment protocols typically involves surgery, radiation therapy, and/or chemotherapy, resulting in debilitating side effects [3]. Mucositis, dysphagia, salivary hypofunction, and xerostomia, as well as long-term complications such as radiation-induced fibrosis, dysphonia, osteoradionecrosis, trismus, and radiation-related caries and frequently described [4].

Ionizing radiation is vital for treating head and neck cancer but can severely impact dental health, leading to management and rehabilitation challenges due to extensive crown destruction, often leaving only the tooth root [5-7]. Radiation-induced cellular changes can complicate bone healing, contraindicating extraction and dental implant placement due to the risk of osteoradionecrosis [8,9]. Fiberglass post adhesively cemented associated with resin composite restoration can be a promising approach to restoring dental function and aesthetics in irradiated patients. Fiberglass posts reduce the risk of root fractures and improved aesthetic outcomes compared to traditional metal cores [10-12]. Additionally, resin composite reconstruction provides a durable and esthetically pleasing restoration that addresses the structural and cosmetic concerns of radiation-induced dental damage [13-16]. Combining these techniques can improve the long-term prognosis and quality of life for these patients.

However, changes in the organic and inorganic composition of irradiated dentin, especially in the cervical and middle thirds of the root, may impact the bonding performance of fiberglass posts [7,17]). Despite advancements in adhesive techniques, the success of cementing fiberglass posts in irradiated teeth remains uncertain. More research on optimizing adhesive protocols and materials tailored to the unique characteristics of irradiated dentin is needed to improve the long-term outcomes of post and core restorations in head and neck cancer survivors undergoing radiation therapy.

Understanding the impact of radiation therapy on the adhesion of fiberglass posts to intrarradicular dentin in head and neck cancer patients is crucial for optimizing dental rehabilitation outcomes. To the best of the authors' knowledge, no clinical study has evaluated the short-term longevity of endodontically treated teeth restored with fiberglass post and direct resin composite crown restorations in patients treated with radiotherapy. This study explores this relationship through a series of case analyses, hypothesizing that radiation-induced changes in dentin structure may compromise the bonding capacity of fiberglass posts. The study employed FDI (World Dental Federation) criteria [18], along with clinical, radiographic, tomographic, and intra- and extra-oral photographic evaluations.

Materials and methods

Study design

This case series study, submitted and approved by the Human Research Ethics Committee of the Federal University of Uberlândia (n. xxxx), was structured and written according to the Case Reports Guideline (CARE). All patients agreed to participate by signing a consent form. From November 2019 to November 2023, four patients underwent rehabilitation with fiberglass posts and resin composite reconstruction, resulting in six treated teeth. The patients were followed up with clinical examinations, panoramic and periapical radiographs, tomographic imaging, intra and extraoral photography, sociodemographic data from medical records, and FDI criteria for reconstructed crowns. Two independent evaluators (VRNS and AMP) assessed and completed the FDI criteria and the epidemiological, clinical, and radiographic parameters.

Eligibility criteria

The inclusion criteria for this study were: patients who underwent radiotherapy to the head and neck with a dosage ranged from 44 to 72 Gy, were older than 18

years, had completed radiotherapy treatment, were indicated for intraradicular fiberglass post cementation, and agreed to the consent terms. Exclusion criteria were: patients not irradiated in the head and neck, with metastases, with teeth lacking satisfactory endodontic treatment, teeth unsuitable for fiberglass post cementation, those with pain, mobility, abscess, fistula, or advanced periodontal disease, and those severely weakened or with severe systemic involvement.

Fiberglass post cementation

Preoperative anamnesis, clinical examination, panoramic radiography, intra-oral and extra-oral photographs were performed for each patient before cementing the fiberglass post to ensure proper restorative and endodontic treatment. All patients were treated by the same operator and using the standard treatment protocol. The fiberglass posts Whitepost DC posts (# 01, FGM, Joinville, SC, Brazil) were cemented using self-adhesive resin cement RelyX U200 (3M Oral Care, St. Paul, MN, USA). Absolute isolation was used, and the root canals were prepared with gates-glidden drills (Dentsply Sirona Endodontics) numbers 02 and 03 in a low-rotation handpiece. The root canal was irrigated using 5 ml of 2.5% sodium hypochlorite solution (Asfer, São Caetano do Sul, SP, Brazil). Standardized removal of gutta-percha was performed in the initial two-thirds of the root. Specific drill compatible with post size number was used for root canal preparation avoiding unnecessary removal of root dentin. The canals were irrigated with 5 ml of 2.5% sodium hypochlorite, followed by a final irrigation with 5 ml of saline solution (LBS Labor, São Paulo, SP, Brazil), and dried using absorbent paper cones compatible with the canal's diameter.

The fiberglass post was checked into the canal for proper adaptation. The portion protruding outside the canal, in the occlusion region, was marked approximately 3 mm below the occlusion line of the antagonist teeth. Excess fiber post was removed with a high-rotation drill. The post was cleaned with 35% hydrogen peroxide for 1 minute [19, 20]. It was then rinsed with water and dried with an air jet. Silane (Prosil, FGM, Joinville, SC, Brazil) was applied for 1 minute and dried with air spray. Self-adhesive automix with an endo tip, resin cement RelyX U200 (3M Oral Care, St. Paul, MN, USA), was applied filling the entire canal [21]. The fiberglass post was inserted into the root canal, allowed to set chemically for 5 minutes, and then photopolymerized for 40 seconds each on the occlusal, buccal and palatal/lingual surfaces, totaling 120 seconds, using the Valo light curing unit (LCU) (Ultradent, South Jordan, UT, USA) with 1200 mW/cm² checked using Resin Marc Calibrator (Blue Light, Halifax, Canada). After cementing the fiberglass post,

an acid etching procedure was performed using 37% phosphoric acid (Condac, FGM, Joinville, SC, Brazil) for 30 seconds on enamel. The acid was rinsed with water for 30 seconds and dried with a gentle stream. A single-bottle universal adhesive (3M Oral Care, St. Paul, MN, USA) was applied in enamel and dentine, and polymerized for 20 seconds. The crown was reconstructed using direct resin composite (IPS Empress Direct, Ivoclar Vivadent, Schaan, Liechtenstein) using 2mm incremental filling technique. Each increment was light curing for 10 seconds using the same LCU

Epidemiological, clinical and radiographic parameters

Between March and April 2024, patients returned for evaluation of teeth restored with fiberglass posts and composite resin. Photographs of the face and intraoral were taken for better visualization and dissemination of images. Teeth were examined using visual and tactile methods, including a mouth mirror, exploring probe, periodontal probe, and air spray, all under appropriate lighting conditions. Three parameters were assessed for each tooth: epidemiological, clinical, and radiographic.

The epidemiological parameter included age, gender, type and location of cancer, treatment interventions (surgery, chemotherapy, radiotherapy or combinations), total and daily ionizing radiation in Gy, type of radiotherapy device, treatment duration and completion, rehabilitated tooth, day of post cementation, follow-up time, type of adhesive resin cement used, and type/diameter of the fiberglass post [19]. The clinical parameter was evaluated using FDI criteria, which examined functional properties (material fracture and retention, marginal adaptation, proximal contact point, shape and contour, and occlusion and wear), biological properties (caries and hard tissue defects at the restoration margin), and aesthetic properties (surface gloss and texture, marginal staining, and color matching). The radiographic parameter was assessed through three types of images: periapical radiograph, to evaluate caries, excess restorations, quality and quantity of canal filling, periapical changes, root length, fiberglass post retention, cementation failures, root insertion level in the bone, and presence of ferrule. Panoramic radiography evaluated the restored tooth in relation to adjacent and antagonist teeth, as well as broader structures like skeletal and dental changes. Tomography evaluated through a three-dimensional aspect, the cementation integrity between fiberglass post and intraradicular dentin, presence of failures or bubbles, restoration or root fractures, dental hard tissue defects, caries or marginal

infiltrations endodontics and periodontal problems such as periapical lesions, root cement resorption and bone attachment level.

Statistical analysis

Descriptive statistical methods were used to describe the epidemiological, clinical (FDI criteria scores), and radiographic data parameters recommended for the rehabilitation of irradiated teeth.

Results

Six teeth from four patients (three men and one woman) were evaluated. The patients, aged 44 to 67 with a mean age of 58.8 ± 10.4 , were treated for tumors in the throat, larynx, supraglottic region, non-Hodgkin's lymphoma, and bone marrow lymphoma. One patient had a lesion on the right side, while the others had bilateral nodular involvement. All patients underwent linear accelerator radiotherapy; two combined it with chemotherapy, one with surgery, and one with both surgery and chemotherapy. The radiotherapy dosage ranged from 44 to 72 Gy, with the time since completion varying from 3 to 27 years. All treated teeth were single-rooted and received a fiberglass post cemented with self-adhesive resin cement between November 2019 and November 2023 (Table 1). Only one patient suffered a fracture of the crown and a small part of the fiberglass post, two years after cementation and reconstruction of the tooth and another patient presented a tooth with a chipped fracture on the buccal surface. In the remaining patients, no failures such as debonding of the fiberglass post, root fracture and pain were observed. Table 2 shows the frequency of the quality of the rehabilitation procedure associated with tooth restorations according to the FDI criteria score.

Table 1. Descriptive analysis of patients and teeth involved in the research.

Patient/tooth	Age/Sex	Type of cancer	Dose Radiation and year of radiotherapy treatment	Date post cimentation
J.S./21	65/ Male	Non-Hodking's Lymphoma	64 Gy/2017	28.06.2023
R.A.D./21	44/ Male	throat cancer	72 Gy/1997	05.11.2019
S.G.L./32	59/Male	laryngeal cancer (lateral wall of the larynx and supraglottic wall)	70.2 Gy/2021	01.11.2023
S.G.L./31	59/Male	laryngeal cancer	70.2 Gy/2021	30.08.2023
S.G.L./42	59/Male	laryngeal cancer	70.2 Gy/2021	22.11.2023
J.D.A.S./21	65/Female	bone marrow lymphoma	44 Gy/2005	16.06.2021

Table 2. Frequency of quality of restorations according to the FDI criteria score.

Parameters	Classification	Excellent	Good	Satisfactory	Unsatisfactory	Bad
Functional properties	Material fracture and retention	4		2		
	Marginal adaptation	3	3			
	Proximal contact point		6			
	Shape and contour	3	3			
	Occlusion and wear		2			
Biologicals properties	Caries at the restoration margin	2	1	3		
	Dental hard tissue defects at the restoration margin		6			
Aesthetic properties	Gloss and surface texture	5	1			
	Marginal staining	2	3	1		
	Color Matching	6				
Patient view	Satisfaction with aesthetics and function	5	1			

According to the clinical parameters based on the FDI criteria scores, Only one patient suffered a fracture of the crown and a small part of the fiberglass post, two years after cementation and reconstruction of the tooth (Fig. 2g) and another patient presented a tooth with a chipped fracture on the buccal surface (Fig.3h). In the remaining patients, no failures such as debonding of the fiberglass post, root fracture and pain were observed. The other patients showed no fracture or retention issues, suggesting good stability of the fiberglass post and resin composite restoration during this short-term evaluation period (Fig.1f and 4h). All teeth showed excellent or good marginal adaptation and contour shape, with good proximal contact points (Fig. 1f, 2h, 3h, 4h). The assessment of occlusion and wear was not

applicable to some patients due to very unstable occlusion and the loss of many posterior teeth. Three teeth showed marginal caries lesions with slight softened dentin (Fig. 4h). No teeth exhibited dental tissue defects at the restoration margins. Most restorations maintained excellent gloss and surface texture. Marginal color changed slightly in one case and remained unchanged in the others. All teeth received the maximum score for color matching. Patients were very satisfied with the restorations, though one patient noted a slight difference at the junction between the tooth and the restoration on the palate of the upper incisor (Table 2).

Analysis of periapical radiographs revealed radiolucent images, indicating caries lesions cavities or bubbles in the reconstructed resin composite crowns and excess restoration material. The periapical region of all incisors showed no lesions. One tooth presented the overfilling (Fig 4d). Bubbles were noted on the resin cement/fiberglass post/dentin interfaces in four teeth: left upper incisor (Fig. 2d) and 42, 31 and 32 (Fig. 4d). Panoramic radiographs showed significant tooth loss in two patients (Fig. 2e and 4e), who occluded only with their anterior teeth. Resorption of alveolar bone crests and radiation-related caries were observed in two patients (Fig. 2f and 4g). The mandibular condyle of one of the patients appeared irregular, symptoms, necessitating long-term follow-up for chewing efficiency (Fig. 2e). Tomography confirmed bubbles at the cement-post interface, satisfactory endodontic fillings, and alveolar bone crests resorption (Fig. 1g, 2i, 3i, and 4i), which was more evident in the tomographic reconstructions (Fig. 1e, 2f, 3f, and 4g).

Discussion

This observational cross-sectional case series study hypothesizing that radiation-induced changes in dentin structure may compromise the bonding capacity of fiberglass posts. In this way, it was evaluated the feasibility of preserving irradiated roots and severely damaged crowns, rehabilitated with fiberglass retainers cemented inside the root canal and crowns reconstructed with composite resin. The main objective was to verify the debonding of the fiberglass post from the root canal and the retention of the restoration. Due to the risk of osteoradionecrosis at the extraction site caused by ionizing radiation, the frequent recommended treatment that involves dental implant installation, and porcelain crown placement is contraindicated [8]. An alternative treatment was proposed in the present study to restore function, aesthetics, and quality of life to the patient, even if temporary involving. The short-term evaluation showed no debonding of the fiberglass posts was observed during the evaluation period.

Ionizing radiation alters neoplastic cells structures by disrupting DNA and RNA chains, thereby preventing cellular replication and leading to cell death [4]. It also impacts healthy tissues within the radiation field, potentially causing radiation-related caries, a significant oral complication [22]. During radiotherapy, the oral mucosa becomes sensitive, taste can abruptly change, and patients often struggle with chewing and swallowing [23]. Weight loss is common, and patients are often prescribed calorie-dense, flavorful foods, which can be highly cariogenic, particularly challenging for those with poor dental hygiene [24]. Ionizing radiation affects salivary glands, leading to hyposalivation, essential for mucous membrane lubrication and dental structures protecting [25]. Dental tissues such as enamel, dentin, and pulp undergo changes in collagen fibers, hydroxyapatite, and water molecules, resulting in tissue delamination typical of irradiated teeth, often prone to caries in unusual locations like cusps and cervical regions [26]. These factors contribute to the rapid progression and destruction of radiation-related caries.

Studies suggest that ionizing radiation may alter intraradicular dentin in the cervical and middle thirds of teeth, potentially compromising the adhesion of fiberglass posts within root canals [7,17]. Some “in vitro” studies have shown reduced resin cement adhesion to irradiated root dentin [27, 28]. However, no clinical trial reports have investigated the retention of fiberglass posts and composite resin crown reconstructions in irradiated roots. The great challenge of research is the standardization of radiotherapy criteria, in a patient with a high mortality rate due to the disease and its consequences, and also to develop a long-term study.

The use of cast-post and core into root canals to support prosthetic crowns has been a longstanding practice [11]. Recent study indicates that adhesive cementation using fiberglass posts forms a single body with the root, reducing the risk of catastrophic fractures compared to metal retainers [29, 30]. This is attributed to the similar modulus of elasticity between fiberglass posts and root dentin [31]. Fiberglass post retainers are increasingly favored for their aesthetic compatibility with the tooth color [30] and their support in adhesive processes for crown reconstructions in composite resin or porcelain [10]. Resin composite crowns are more cost-effective than porcelain crowns. During patient follow-ups, minor adjustments were occasionally needed for restored crowns due to chewing-related fractures, which were promptly addressed by the professional[31]. Currently, the idea of using a fiberglass pin mesh, replacing the fiberglass pin, has become

widespread. However, research concludes that fiber pins are still proven to be superior to meshes, presenting a higher survival rate [32].

In one patient had the resin composite crown fractured after two years of follow-up, leaving 3 mm of ferrule and the fiberglass post exposed. The fracture was not catastrophic allowing the crown repair using the same direct resin composite restoration. This case was evaluated 6 months later and remained quite satisfactory. Tomography showed significant buccal bone loss, probably due to occlusion primarily involving the anterior teeth. Three of the these patients have multiple missing teeth, particularly in the posterior region, leading to chewing mainly with their anterior teeth. These teeth are intended for cutting food and protecting the posterior teeth during excursive chewing movements [33]. They have single roots and should not be overloaded, as this can lead to fractures, periapical and alveolar bone resorption, pulp necrosis from trauma or changes in their inclination within the dental arch [34]. Despite occluding mainly with anterior teeth, patients generally did not experience severe fiberglass post fractures or catastrophic root fractures, suggesting a very efficient masticatory adaptation. Changes in masticatory muscles caused by ionizing radiation reduce muscle power, minimizing the force on the front teeth. Additionally, a diet of softer foods further reduces the risk of damage to the restorations [35].

The marginal adaptation was slightly compromised in some teeth. This aspect can be due dental tissue alterations caused by ionizing radiation, the hyposalivation, poor dental hygiene, high-calorie foods consume. Studies with a larger number of patients would make the results more robust and reliable. However, the clinical control of radiotherapy patients ends up being somewhat delicate, as in some cases the diet is changed and dental hygiene can also be compromised by oral changes. Studies to improve the behavior of adhesive resin cements in dental tissues altered by ionizing radiation would be important. The caries lesion prevention protocols, equipment with more restrictive ionizing radiation distribution to neoplastic cells and more studies to improve the understanding of these irradiated patients are still very necessary to improve the quality of life of these patients.

In this observational cross-sectional case series study, no debonding of fiberglass posts occurred after clinical and radiographic follow-up during the short-term evaluation. Ionizing radiation caused radiation-related caries lesions, leading to the destruction of nearly the entire dental crown. The risk of osteoradionecrosis contraindicated extraction and dental implants installation. Although the restorative

protocol remains a challenge, dental rehabilitation for endodontically treated teeth with severe coronal structure loss using fiberglass post adhesively cemented using self-adhesive cement and resin composite reconstruction showed promising results. All restorations were satisfactory according to FDI criteria scores and radiographic images.

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References

1. Klein J, Livergant J, Ringash J (2014) Health related quality of life in head and neck cancer treated with radiation therapy with or without chemotherapy: a systematic review. *Oral Oncol.* 50(4):254-62. doi: <http://doi.org/10.1016/j.oraloncology.2014.01.015>.
2. Marur S, Forastiere AA (2016) Head and Neck Squamous Cell Carcinoma: Update on Epidemiology, Diagnosis, and Treatment. *Mayo Clin Proc.* 91(3):386-96. doi: 10.1016/j.mayocp.2015.12.017.
3. Teymoortash A, Ferlito A, Halmos GB (2016) Treatment in elderly patients with head and neck cancer : A challenging dilemma. *HNO.* 64(4):217-20. doi: 10.1007/s00106-016-0138-6.
4. Moore C, McLister C, Cardwell C, O'Neill C, Donnelly M, & McKenna, G (2020) Dental caries following radiotherapy for head and neck cancer: A systematic review. *Oral Oncology Journal.* 100, Article 104484. <https://doi.org/10.1016/j.oraloncology.2019.104484>;
5. Lu H, Zhao Q, Guo J, et al., (2019) Direct radiation-induced effects on dental hard tissue. *Radiat Oncol.* 14(1):5. Doi: 10.1186/s13014-019-1208-1.

6. Palmier NR, Ribeiro ACP, Fonsêca JM, et al. (2017) Radiation-related caries assessment through the International Caries Detection and Assessment System and the Post-Radiation Dental Index. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 124(6):542-547. doi:10.1016/j.oooo.2017.08.019.
7. Pelloso AM, de Miranda RR, Rossi ME, Bianchini ALB, Marcelino FAS, da Silva ELC, Novais VR (2022) Chemical analysis of irradiated root dentin and its interaction with resin cements. *Clin Oral Investig.* 2022 Jun;26(6):4315-4325. doi: 10.1007/s00784-022-04395-z.
8. Jawad H, Hodson NA, Nixon PJ (2015) A review of dental treatment of head and neck cancer patients, before, during and after radiotherapy: part 1. *Br Dent J.* 218(2):65-8. doi: 10.1038/sj.bdj.2015.29.
9. Bhandari S, Soni BW, Bahl A, Ghoshal S (2020) Radiotherapyinduced oral morbidities in head and neck cancer patients. *Spec Care Dentist.* 40(3):238–250. <https://doi.org/10.1111/scd.12469>;
10. Santos-Filho PC, Veríssimo C, Soares PV, Saltarello RC, Soares CJ, Martins LRM (2014) Infuence of ferrule, post system, and length on biomechanical behavior of endodontically treated anterior teeth. *J Endod.* 40(1):119–123. <https://doi.org/10.1016/j.joen.2013.09.034>
11. Sarkis-Onofre R, Amaral Pinheiro H, Poletto-Neto V, Bergoli CD, Cenci MS, Pereira-Cenci T (2020) Randomized controlled trial comparing glass fiber posts and cast metal posts. *J Dent.* ;96:103334. doi: 10.1016/j.jdent.2020.103334.
12. de Mendonça A F, e Souza, G M d, de Mendonça B F, & Ellakwa (2021) A. Clinical Performance of Cast Metal and Fiber Post Retained Restorations in Endodontically Treated Teeth: A Systematic Review and Meta-Analysis. *European Journal of Dental and Oral Health.* 2(6), 5–12. <https://doi.org/10.24018/ejdent.2021.2.6.117>.
13. Soares CJ, Roscoe MG, Castro CG, Santana FR, Raposo LH, Quagliatto PS, Novais VR (2011) Effect of gamma irradiation and restorative material on the biomechanical behaviour of root filled premolars. *Int Endod J.* 44(11):1047-54. doi: 10.1111/j.1365-2591.2011.01920.x.
14. Dudley A, Tjan A H L, & Grant B E (2014). Effect of surface treatment and type of cement on the retention of fiber posts in root canals. *Journal of Prosthetic Dentistry,* 112(5), 1234-1239. doi: 10.1111/j.1600-0722.2008.00536.x.

- 15.** Yamin PA, Pereira RD, Lopes FC, Queiroz AM, Oliveira HF, Saquy PC, Sousa-Neto MD (2018) Longevity of bond strength of resin cements to root dentine after radiation therapy. *Int Endod J.* 51(11):1301-1312. doi: 10.1111/iej.12945.
- 16.** Lopes FC, Roperto R, Akkus A, de Queiroz AM, Francisco de Oliveira H, Sousa-Neto MD (2020) Effect of carbodiimide and chlorhexidine on the bond strength longevity of resin cement to root dentine after radiation therapy. *Int Endod J.* 53(4):539-552. doi: 10.1111/iej.13252.
- 17.** Pelloso AM, Rossi ME, Miranda RR, Soares CJ, Novais VR (2024) Radiotherapy in the head and neck region influences the chemical and mechanical properties of intraradicular dentin. *Arch Oral Biol.* 158:105868. doi: 10.1016/j.archoralbio.2023.105868.
- 18.** Hickel R, Mesinger S, Opdam N, Loomans B, Frankenberger R, Cadenaro M, Burgess J, Peschke A, Heintze SD, Kühnisch J (2023) Revised FDI criteria for evaluating direct and indirect dental restorations-recommendations for its clinical use, interpretation, and reporting. *Clin Oral Investig.* 27(6):2573-2592. doi: 10.1007/s00784-022-04814-1.
- 19.** de Sousa Menezes M, Queiroz EC, Soares PV, Faria-e-Silva AL, Soares CJ, Martins LR (2011) Fiber post etching with hydrogen peroxide: effect of concentration and application time. *J Endod* 37(3):398-402. doi: 10.1016/j.joen.2010.11.037.
- 20.** Valdivia AD, Novais VR, Menezes Mde S, Roscoe MG, Estrela C, Soares CJ (2014) Effect of surface treatment of fiberglass posts on bond strength to root dentin. *Braz Dent J.* 25(4):314-20. doi: 10.1590/0103-6440201300143.
- 21.** Silva NRD, Rodrigues MP, Bicalho AA, Soares PBF, Price RB, Soares CJ (2019) Effect of Resin Cement Mixing and Insertion Method into the Root Canal on Cement Porosity and Fiberglass Post Bond Strength. *J Adhes Dent.* 21(1):37-46. doi: 10.3290/j.jad.a41871.
- 22.** Gupta N, Pal M, Rawat S, Grewal MS, Garg H, Chauhan D, Ahlawat P, Tandon S, Khurana R, Pahuja AK, Mayank M, Devnani B (2015) Radiation-induced dental caries, prevention and treatment - A systematic review. *Natl J Maxillofac Surg.* 6(2):160-6. doi: 10.4103/0975-5950.183870.
- 23.** Beech N, Robinson S, Porceddu S, Batstone M (2014) Dental management of patients irradiated for head and neck cancer. *Aust Dent J* 59:20-8. doi: 10.1111/adj.12134.

- 24.** Kaluzny J, Wierzbicka M, Nogala H, Milecki P, Kopec T (2014) Radiotherapy induced xerostomia: Mechanisms, diagnostics, prevention and treatment – evidence based up to 2013 *Otolaryngol Pol.* 68:1–14. doi: 10.1016/j.otpol.2013.09.002.
- 25.** McGuire JD, Mousa AA, Zhang BJ, Todoki LS, Huffman NT, Chandrababu KB, Moradian-Oldak J, Keightley A, Wang Y, Walker MP, Gorski JP (2014) Extracts of irradiated mature human tooth crowns contain MMP-20 protein and activity. *J Dent.* 42(5):626-35. doi: 10.1016/j.jdent.2014.02.013.
- 26.** Velo, M.M.d.A.C., Farha, A.L.H., da Silva Santos, P.S. *et al* (2018) Radiotherapy alters the composition, structural and mechanical properties of root dentin in vitro. *Clin Oral Invest* **22**, 2871–2878. <https://doi.org/10.1007/s00784-018-2373-6>
- 27.** Campi LB, Lopes FC, Soares LES, de Queiroz AM, de Oliveira HF, Saquy PC, de Sousa-Neto MD (2019) Effect of radiotherapy on the chemical composition of root dentin. *Head Neck.* 41(1):162-169. doi: 10.1002/hed.25493.
- 28.** Abdulrab S, Geerts G, Al-Maweri SA, Alhajj MN, Alhadainy H, Ba-Hattab R (2023) The influence of horizontal glass fiber posts on fracture strength and fracture pattern of endodontically treated teeth: A systematic review and meta-analysis of in vitro studies. *J Prosthodont.* 32(6):469-481. doi: 10.1111/jopr.13654.
- 29.** Oulghazi I, El Yamani A, Morchad B (2024) Factors Influencing Vertical Radicular Fractures in Teeth Supported by Metallic Dental Core: A Scoping Review. *Clin Cosmet Investig Dent.* 21;16:101-114. doi: 10.2147/CCIDE.S458697.
- 30.** Veríssimo C, Simamoto Júnior PC, Soares CJ, Noritomi PY, Santos-Filho PC (2014) Effect of the crown, post, and remaining coronal dentin on the biomechanical behavior of endodontically treated maxillary central incisors. *J Prosthet Dent.* 2014 Mar;111(3):234-46. doi: 10.1016/j.prosdent.2013.07.006.
- 31.** Freedman GA. (2001) Esthetic post-and-core treatment. *Dent Clin North Am.* 2001 Jan;45(1):103-16. PMID: 11210689.
- 32.** Ribeiro MTH, Oliveira G, Oliveira HLQ, Mendoza LCL, Melo C, Silva Peres T, Soares CJ (2023) Survival of severely compromised endodontically treated teeth restored with or without a fiber glass post. *J Appl Oral Sci.* 27;31:e20230241. doi: 10.1590/1678-7757-2023-0241.
- 33.** Koolstra JH (2002) Dynamics of the human masticatory system. *Crit Rev Oral Biol Med.* 13(4):366-76. doi: 10.1177/154411130201300406.

34. Niwa K, Takahashi N (2023) Elucidation of the relationship between masticatory muscle activity and masticatory movement. Report 1. Mechanism of occlusal force generation. Clin Exp Dent Res.9(3):472-480. doi: 10.1002/cre2.725.
35. Xia J, Zheng J, Huang D, Tian ZR, Chen L, Zhou Z, Ungar PS, Qian L (2015) New model to explain tooth wear with implications for microwear formation and diet reconstruction. Proc Natl Acad Sci U S A. 25;112(34):10669-72. doi: 10.1073/pnas.1509491112.

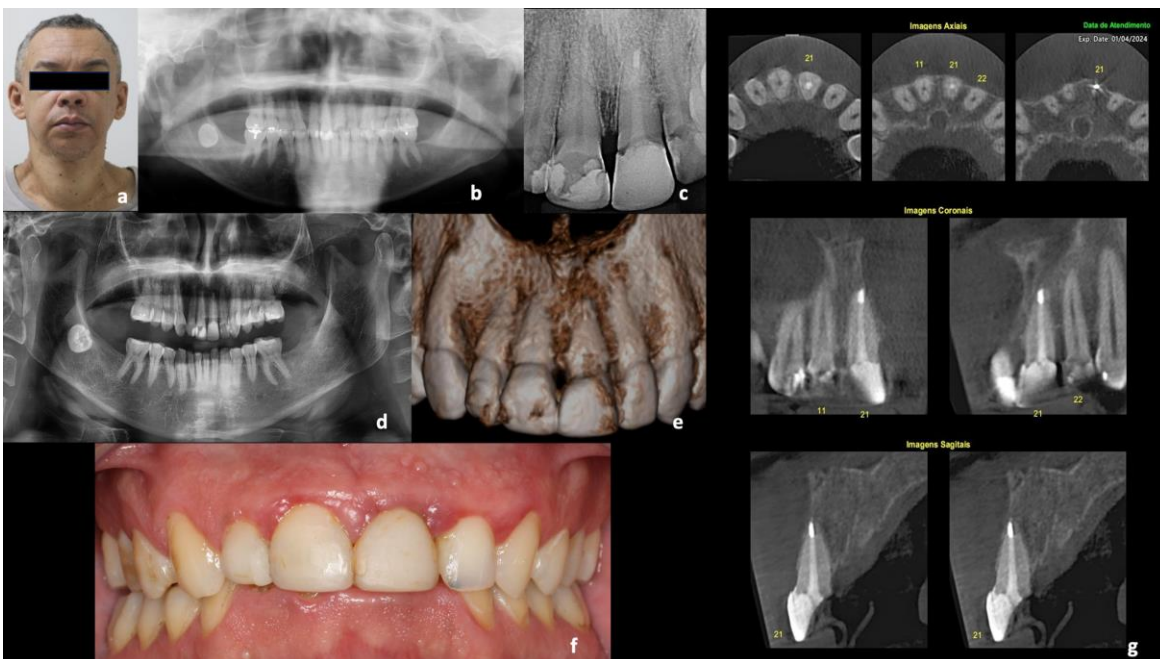


Figure 1. (a) Frontal face photography, (b) Initial panoramic x-ray, (c) Final periapical radiograph, (d) Final panoramic x-ray, (e) Final CBCT reconstruction, (f) Final Intra oral photography, (g) Final CBCT scan.

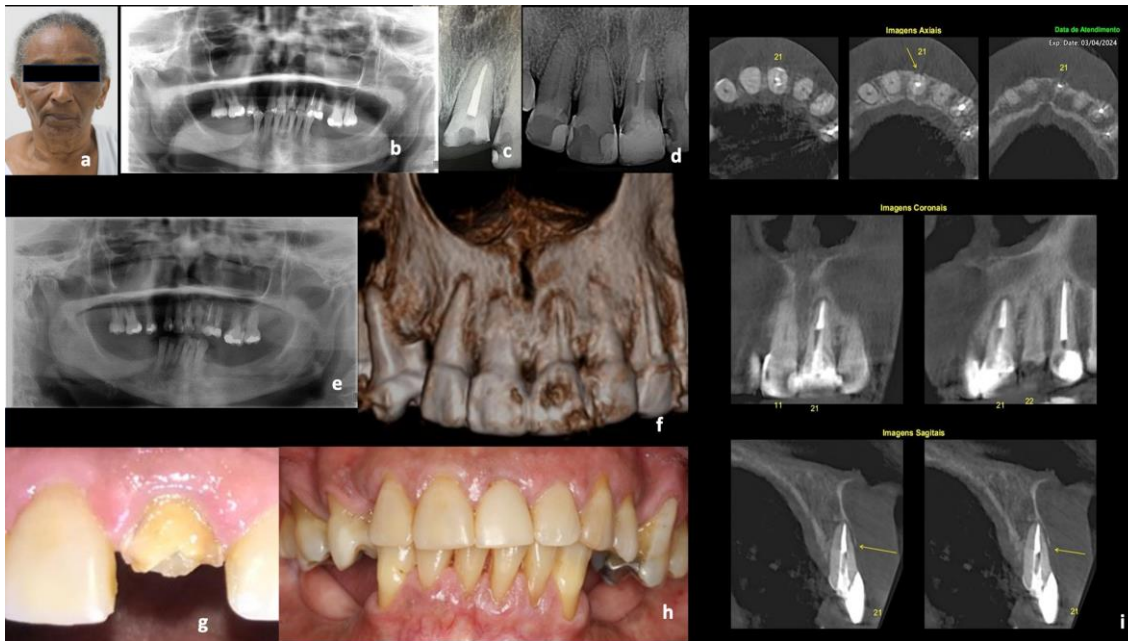


Figure 2. (a) Frontal face photography, (b) Initial panoramic x-ray, (c) Initial periapical radiograph, (d) Final periapical radiograph, (e) Final panoramic x-ray, (f) Final CBCT reconstruction, (g) Fracture of the restoration and fiberglass post, (h) Final Intra oral photography, (i) Final CBCT scan.

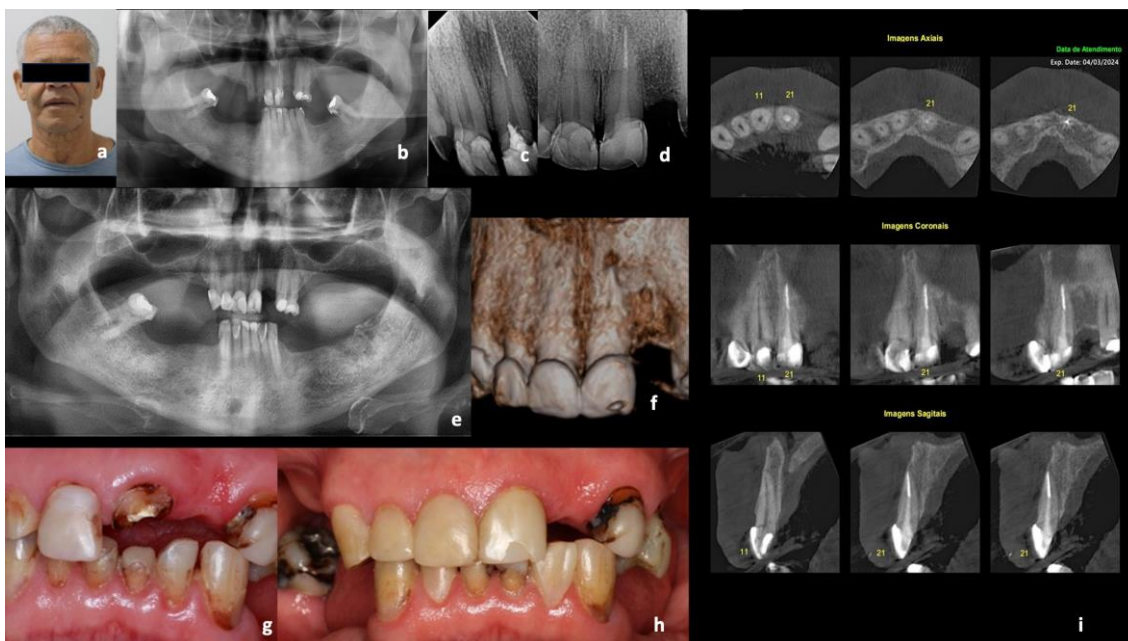


Figure 3. (a) Frontal face photography, (b) Initial panoramic x-ray, (c) Initial periapical radiograph, (d) Final periapical radiograph, (e) Final panoramic x-ray, (f) Final CBCT reconstruction, (g) Initial Intra oral photography, (h) Final Intra oral photography, (i) Final CBCT scan.

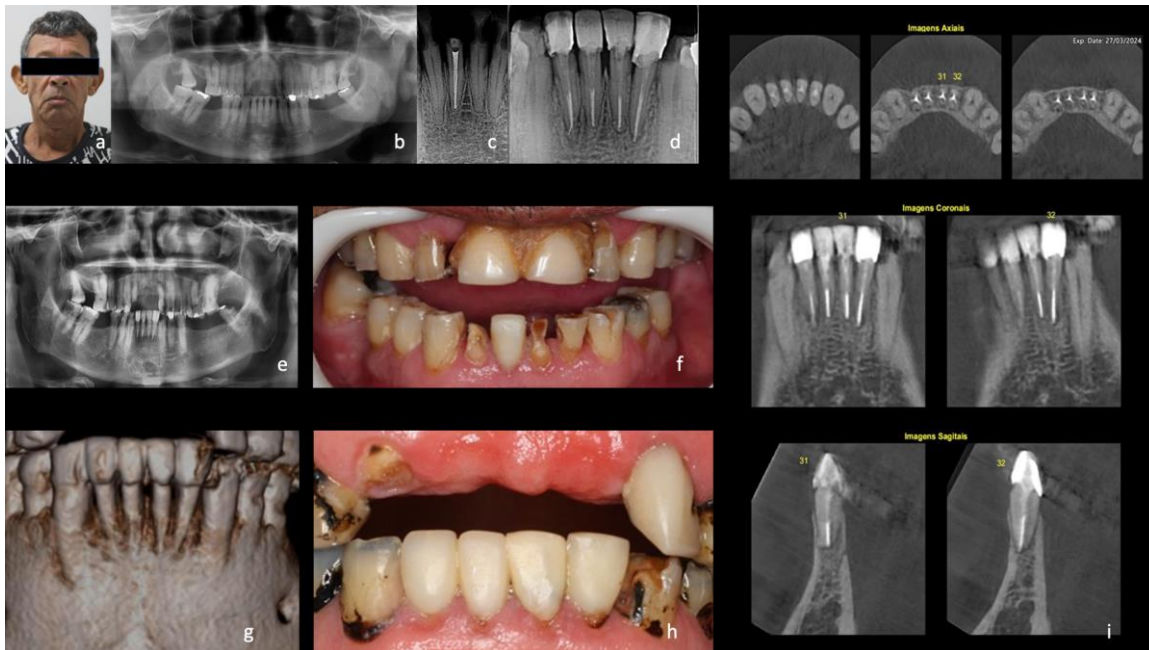


Figure 4. (a) Frontal face photography, (b) Initial panoramic x-ray, (c) Initial periapical radiograph, (d) Final periapical radiograph, (e) Final panoramic x-ray, (f) Initial intra oral photography, (g) Final CBCT reconstruction, (h) Final Intra oral photography, (i) Final CBCT scan.

2. 3. CAPÍTULO 3, ARTIGO 3

INFLUÊNCIA DA RADIOTERAPIA NO TECIDO DA POLPA DENTÁRIA EM PACIENTE COM CÂNCER DE CABEÇA E PESCOÇO. RELATO DE CASO.

INFLUENCE OF RADIOTHERAPY ON DENTAL PULP TISSUE IN PATIENT WITH HEAD AND NECK CANCER. CASE REPORT.

Artigo a ser submetido para publicação no periódico Journal of Endodontics

INFLUENCE OF RADIOTHERAPY ON DENTAL PULP TISSUE IN PATIENT WITH HEAD AND NECK CANCER. CASE REPORT.

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Abstract

Evaluate the pulp condition, through the cold thermal test of pulp vitality, in patients with cancer in the head and neck region treated with radiotherapy and evaluated at 6 and 12 months post-treatment. Teeth 12, 11, 21, and 23 were evaluated using the cold thermal test of pulp vitality, along with clinical examination and panoramic, periapical radiography, and tomography, 6 and 12 months after radiotherapy treatment. After six months, teeth 12, 11, 21, and 23 presented a negative response to the cold thermal pulp vitality test, with no clinical, periapical, periodontal, or carious changes observed in clinical exams and imaging. Twelve months post-treatment, tooth 23 responded positively to the cold thermal pulp vitality test, while teeth 11 and 21 showed a slight response to the test and tooth 12 remained non-responsive. Assessment of clinical and imaging results were similar to previous follow-up. This case report study concludes that ionizing radiation in head and neck cancer patients temporarily alters the pulp condition. Six months after radiotherapy, teeth showed a negative response to the cold thermal pulp vitality test. However, 12 months post-treatment, some teeth exhibited a return of pulp vitality response.

Significance: Accurate diagnosis of pulp condition is crucial for dental treatment. Radiotherapy can alter the response to the pulp vitality test, potentially leading to an incorrect diagnoses. Understanding the effects of ionizing radiation on pulp condition can help prevent diagnostic errors.

Keywords: case report; cold thermal test of pulp vitality; head and neck neoplasms; radiotherapy.

Introduction

Malignant neoplasms in the head and neck region are usually treated with radiotherapy¹. Ionizing radiation alters the molecular properties of neoplastic cells, destroying them. Nevertheless, ionizing radiation can also affect normal structures

within the radiation field, leading to significant consequences for the patient's quality of life^{2,3}. Scientific evidence indicates direct effects of ionizing radiation on dental structures, mainly enamel and coronal dentin⁴⁻⁶. However, changes at the root level and in pulpal tissues are not yet well understood⁷⁻¹¹. Some patients may develop radiation-related caries, a very aggressive form of carious lesion that quickly damages dental structures¹². Many of these patients, even those with caries very close to the pulp, do not report pain¹³. Other teeth, even intact ones, may not show painful sensitivity during pulp sensitivity tests with cold stimulation¹⁴.

Radiotherapy affects the pulp condition of irradiated teeth, potentially causing pulp necrosis or temporary changes^{8,15}. Ionizing radiation may alter dental pulp microcirculation¹⁶, leading to reduced vascularization, fibrosis, pulp tissue atrophy, and arteriole walls thickening¹³. Ionized pulp tissue can undergo a sequence of events: hyperemia, vascular inflammation, ischemia, and possibly hypoxia and necrosis¹³. Pulpal blood flow may normalize depending on the severity of involvement and recovery time¹⁵. When pulpal inflammation is reversible, the recovery of healthy oxygenation levels and normal blood flow characteristics are reestablished¹⁵.

The condition of the pulp is extremely important for evaluating its health or pathology when planning dental treatment. The pulp vitality test is a crucial method for diagnosing pulp condition¹⁷. When sensitivity a cold thermal pulp vitality test on the surface of the crown responds positively with pain that quickly ceases, it indicates that pulp vitality is normal. If the pain does not cease quickly after the stimulus, it may suggest pulp inflammation. If the patient does not show any sensitivity to the cold stimulus, it indicates pulp necrosis. Teeth with necrotic pulps become a shelter for bacterial contamination and multiplication, leading to periradicular bone resorption and an increased risk of septicemia for the patient¹⁸. In patients with irradiated teeth, diagnosing the pulp condition becomes quite challenging, as the pulp could be in a state of transient hypoxia or even necrotic^{19,20}.

In this context, the objective of this case report was to evaluate the influence of radiotherapy on the pulp conditions of irradiated teeth in a patient with cancer in the head and neck region. The patient was treated with radiotherapy and evaluations were carried out 6 months and 12 months after the end of treatment. To diagnose the pulp condition, a cold thermal pulp vitality test, clinical examination, periapical and panoramic radiographs, and tomography of the involved teeth were used.

Case Report

This study was submitted and approved by the Ethics Research Committee of the Faculty of Dentistry at the Federal University of Uberlândia, Brazil (FOUFU), under the number CAAE ----- . The patient agreed to participate in the research by signing an informed consent form, thereby approving their participation in the study. This research is a case report that discusses the condition of the pulp after ionizing radiation treatment for cancer in the head and neck region.

Patient J.L.A., 65 years old, attended the SOPRO project (Preventive and Restorative Dental Support for Cancer Patients) on October 4, 2023, at the Faculty of Dentistry of the Federal University of Uberlândia, for follow-up after radiotherapy treatment. His main complaint was the lack of teeth and seeking to rehabilitating lost teeth. He presented with a history of glottic laryngeal carcinoma - T3N0M0. Carcinoma treatment began with a biopsy of the lesion in the left vocal fold, confirming the diagnosis of squamous cell carcinoma. For the treatment of cancer, six cycles of chemotherapy (Cisplatina, Accord, São Paulo, SP, Brazil) and 33 radiotherapy sessions were carried out, totaling 59.4 Gy, ending in March 2023. The linear acceleration radiotherapy device (Elekta, Stockholm, Sweden) was used, which administered ionizing radiation through VMAT (Volumetric Modulated Arc therapy).

Six months after completing cancer treatment, a detailed medical history was taken, including information about the cancer. The dental anamnesis was obtained in detail. The patient significant weight loss and changes in swallowing, taste, and masticatory muscle power immediately after radiotherapy. As part of the project's care protocol, a periogram was recorded, and supragingival and subgingival scrapings were performed. Saliva was also collected to determine salivary flow and pH. The patient presented with hyposalivation and xerostomia, confirmed by a stimulated salivary flow of 0.340 ml/minute (the ideal being 2.0 ml/minute). The intraoral saliva pH was 6, and the extraoral pH was 7, within the neutral range. The patient received oral hygiene guidance and was prescribed a 0.05% sodium fluoride mouthwash for daily use after meals. The patient presented with few radiation-related caries and non-carious cervical lesions.

Tooth 22 had endodontic treatment and a metal-ceramic crown retained with a cast metal core inside the root canal. An extensive cavity in tooth 13 required endodontic treatment (Fig. 1F and G). Teeth 12, 11, 21 and 23 underwent the pulp sensitivity test to cold stimulation (Endo Ice spray ice, Maquira, Maringá, PR, Brazil).

All teeth responded negatively to the pulp sensitivity test, 6 months after the end of radiotherapy. The removal of extensive caries on teeth 12 and 23, was carried out without the need for anesthesia and without any painful sensitivity. Due to the proximity to the pulp, these teeth had their cavity protected with calcium hydroxide cement (Dycal, Dentsply Caulk, Milford, DE, USA) and restored with composite resin (Fig. 1H). Teeth 11 and 21 were aesthetically improved with composite resin (Fig. 1A and B). All restorations were performed by the same operator (Fig. 2B, C and D). The pulp sensitivity test to cold stimulation was performed by another operator, a specialist in endodontics (Fig. 1C-G, I-N).

Twelve months after radiotherapy treatment, a new evaluation was carried out, with a pulp sensitivity test to cold stimulation, by the same operator who carried out the initial evaluation. Only tooth 23 presented a positive pulp vitality test and no tooth presented pain on vertical percussion. Teeth 11 and 21 most of the time did not respond to the cold test. When he responded to the stimulus, it was discreet. Tooth 12 did not respond to the pulp vitality test. New panoramic, periapical radiography, and tomography images of the investigated teeth were taken, seeking to evaluate possible carious, periodontal changes, periapical resorptions resulting from pulp changes or resorptions of the alveolar bone crest. The images showed the same aspects as at the beginning of the 6-month dental treatment (Fig. 2E-M).

Discussion

Ionizing radiation affected the pulp condition of teeth within the irradiation field in this case report study. The initial examination, six months after radiotherapy, showed a negative pulp sensitivity test to cold stimulation for teeth 12, 11, 21, and 23. In the second evaluation, 12 months pos-radiotherapy, tooth 12 still showed no sensory response, while tooth 23 began to respond to cold stimulation. Teeth 11 and 21 exhibited mild painful sensitivity to cold, suggesting possible recovery of normal pulp condition. Teeth 12 and 23 had deep cavities close to the pulp, which were treated with calcium hydroxide cement and restored with composite resin, without anesthesia or pain reported by the patient during the procedure. After 12 months, the patient reported no symptoms, and radiographic and tomographic images showed no periapical changes, remaining consistent with images taken six months prior. Research indicates a decrease in blood flow in the pulp tissue, particularly up to six months pos-radiotherapy, with normal pulp condition gradually being restored over time¹⁴.

The study demonstrated alteration in pulp sensitivity in the first year after radiotherapy treatment, highlighting the importance of monitoring pulp condition for several years to confirm the recovery of pulp vitality^{8,14-16}. Transient hyperemia, reduced vascular flow, fibrosis, dental pulp atrophy, and even vascular hypoxia can occur temporarily following radiotherapy treatment, which can lead to inaccurate diagnoses, particularly when conducting cold thermal tests of pulp vitality^{21,22}.

Diagnosis pulp condition remains a challenge for dental surgeons, as commonly used thermal and electrical pulp vitality tests assess pulp sensitivity indirectly through stimuli applied to the surface of the dental crown and rely on the patient's subjective response to pain²³. The neurosensory system is more resilient than the vascular system, and in cases of severe inflammation, pulp vascularization may be compromised while nerve fibers may still respond positively to cold pulp vitality tests²⁴. Alternative methods for assessing pulp condition, such as laser doppler flowmetry and pulse oximetry, which measure blood flow and oxygen saturation, could potentially enhance diagnostic accuracy²⁵⁻²⁸.

During initial radiotherapy treatment, inflammation of pulp tissues is observed, and hyperemia can increase tooth sensitivity^{13,22}. This process includes obliteration of dentinal tubules, preceded by degeneration of odontoblastic processes, directly affecting pulp tissue vascularization and metabolism, particularly in the area of odontoblastic process endings^{13,29}. During this phase, there is a reduction in vascular volume and flow, alongside increase intrapulpal pressure³⁰. Chemical mediators released during this phase can stimulate pulp remodeling and vasculogenesis, facilitating recovery of tissues altered by ionizing radiation¹⁵.

At this stage, a decrease in oxygen saturation and subsequent hypoxia, reduced blood flow, and an inhibitory effect primarily on delta A nerve fibers with fast nerve conduction can be observed³¹. C nerve fibers, which have slower conduction and are thicker and more centrally located than delta A fibers, are less sensitive to decreased blood flow²⁰. The cellular matrix of pulp tissue contains stem cells capable of differentiating into vascular tissue, thus maintaining blood supply after ionizing radiation³². After periods longer than one year of radiotherapy treatment, normal patterns in dental tissues for nervous structures, blood vessels, and dental pulp cells have been observed. It suggests potential sensory recovery, especially over extended durations^{14,22}.

Neurons are cells that characterize the nervous system and are responsible for forming synapses, which are passages for transmitting electrical or chemical

signals to other neurons, connecting sensory organs. Several proteins related to synapses include excitatory neurotransmitters like adrenaline, noradrenaline, and dopamine, as well as inhibitory neurotransmitters such as GABA (gamma-aminobutyric acid) receptors. Calcium channels in the membranes of excitable cells are crucial for the electrical voltage of nerve impulses³³. Studies indicate that ionizing radiation alters the passage of electrical impulses between neurons by affecting GABA receptors and causing an abnormal increase in calcium ion channels³⁴. Ionizing radiation can also induce chronic inflammation accompanied by elevated levels of pro-inflammatory cytokines³⁵, potentially leading to the degeneration of dopaminergic cells, reducing dopamine levels, and inhibiting nerve impulses³⁶.

The size of nerves and the degree of myelination of nerve fibers are crucial in their response to stimuli. Myelinated delta A fibers regulate preganglionic sympathetic and parasympathetic functions, while unmyelinated type C fibers regulate postganglionic autonomic function in pulp tissues, transmitting nociceptive and thermal signals. These post-radiotherapy effects may explain the absence of pain, even in deep carious lesions³⁷.

This case report confirms the absence of pulp sensitivity in the upper anterior teeth six months after radiotherapy treatment, as well as the return of pulp sensitivity in some teeth evaluated after twelve months of radiotherapy treatment. We recommend clinical and radiographic evaluations every six months to monitor the pulp condition of the evaluated teeth, provided there are no changes in the radiographic images, sensitivity tests, or patient symptoms. This approach helps confirm a complete return to normal pulp condition, and avoids unnecessary treatments.

Conclusion

This case report study concluded that ionizing radiation in head and neck cancer patients temporarily modified the pulp condition. Six months after radiotherapy, teeth showed a negative response to the cold thermal pulp vitality test. However, 12 months post-treatment, some teeth exhibited a return of pulp vitality response.

Acknowledgment

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References

1. Moore, C., McLister, C., Cardwell, C., O'Neill, C., Donnelly, M., & McKenna, G. Dental caries following radiotherapy for head and neck cancer: A systematic review. *Oral Oncology Journal*, 2020; 100, Article 104484. <https://doi.org/10.1016/j.oraloncology.2019.104484>.
2. Tolentino ES., Centurion BS., Ferreira LHC., Souza AP., Damante JH., Rubira-Bullen IRF. Oral adverse effects of head and neck radiotherapy: literature review and suggestion of a clinical oral care guideline for irradiated patients. *J Appl Oral Sci.* 2011;19(5):448-54. doi: 10.1590/s1678-77572011000500003.
3. Jawad H, Hodson NA, Nixon PJ. A review of dental treatment of head and neck cancer patients, before, during and after radiotherapy: part. 2. *Br Dent J.* 2015 Jan; 218(2):69-74. <https://doi.org/10.1038/sj.bdj.2015.29>
4. Rodrigues RB., Soares CJ., Junior PCS., Lara VC., Arana-Chavez VE., Novais VR. Influence of radiotherapy on the dentin properties and bond strength. *Clin Oral Investig.* 2018; 22(2):875-883. doi: 10.1007/s00784-017-2165-4.
5. Miranda RR, Ribeiro TE, Silva ELCD, Simamoto Júnior PC, Soares CJ, Novais VR. Effects of fractionation and ionizing radiation dose on the chemical composition and microhardness of enamel. *Arch Oral Biol.* 2021 Jan;121:104959. doi: 10.1016/j.archoralbio.2020.104959. Epub 2020 Nov 2. PMID: 33171393.
6. Douchy L, Gauthier R, Abouelleil-Sayed H, Colon P, Grosogeat B, Bosco J. The effect of therapeutic radiation on dental enamel and dentin: A systematic review. *Dent Mater.* 2022 Jul;38(7):e181-e201. doi: 10.1016/j.dental.2022.04.014. Epub 2022 May 12. PMID: 35570008.

7. Velo MMAC, Farha ALH, da Silva Santos PS, Shiota A, Sansavino SZ, Souza AT, et al. Radiotherapy alters the composition, structural and mechanical properties of root dentin in vitro. *Clin Oral Investig*. 2018;22(8):2871-8. doi: 10.1007/s00784-018-2373-6.
8. Gupta N., Grewal MS., Gairola M., Grewal S., Ahlawat P. Dental Pulp Status of Posterior Teeth in Patients with Oral and Oropharyngeal Cancer Treated with Radiotherapy: 1-year Follow. *J Endod*. 2018; 44(4):549-554. doi:10.1016/j.joen.2017.12.017.
9. Campi LB, Lopes FC, Soares LES, de Queiroz AM, de Oliveira HF, Saquy PC, de Sousa-Neto MD. Effect of radiotherapy on the chemical composition of root dentin. *Head Neck*. 2019 Jan;41(1):162-169. doi: 10.1002/hed.25493. Epub 2018 Dec 15. PMID: 30552849.
10. Pelloso AM, de Miranda RR, Rossi ME, Bianchini ALB, Marcelino FAS, da Silva ELC, Novais VR. Chemical analysis of irradiated root dentin and its interaction with resin cements. *Clin Oral Investig*. 2022 Jun;26(6):4315-4325. doi: 10.1007/s00784-022-04395-z. Epub 2022 Feb 11. PMID: 35149905.
11. Pelloso AM, Rossi ME, Miranda RR, Soares CJ, Novais VR. Radiotherapy in the head and neck region influences the chemical and mechanical properties of intraradicular dentin. *Arch Oral Biol*. 2024 Feb;158:105868. doi: 10.1016/j.archoralbio.2023.105868. Epub 2023 Dec 1. PMID: 38070323.
12. Gupta N., Pal M., Rawat S., Grewal MS., Garg H., Chauhan D., Ahlawat P., Tandon S., Khurana R., Pahuja AK., Mayank M., Devnani B. Radiation-induced dental caries, prevention and treatment - A systematic review. *National Journal of Maxillofacial Surgery*. 2015; 6, 160-6. doi: 10.4103/0975-5950.183870.
13. Knowles JC., Chalian VA., Shidnia H. Pulp innervation after radiation therapy. *J Prosthet Dent* 1986; 56:708-11. doi: 10.1016/0022-3913(86)90150-2.
14. Ribeiro TE, Novais VR, Estrela C, Santana MLL, Rossi-Fedele G, Decurcio DA. Does radiotherapy treatment alter the pulp condition in patients with head and neck cancer? A systematic review. *Braz Oral Res*. 2023 Jul 28;37:e079. doi: 10.1590/1807-3107bor-2023.vol37.0079. PMID: 37531515.
15. Kataoka SHH., Setzer FC., Gondim-Junior E., Fregnani ER., Moraes CJP., Pessoa OF., Gavini.G., Caldira CL. Late effects of head and neck radiotherapy on pulp vitality assessed by pulse oximetry. *J Endod* 2016; 42(6):886-9. Doi: 10.1016/j.joen.2016.02.016.
16. Garg H., Grewal MS., Rawat S., Suhag A., Sood PB., Grewal S., Ahlawat P. Dental pulp status of posterior teeth in patients with oral and oropharyngeal cancer treated

- with concurrent chemoradiotherapy. *J Endod.* 2015; 41(11):1830-33. doi: 10.1016/j.joen.2015.08.006.
17. Alghaithy, R. A., & Qualtrough, A. J. E. (2016). Pulp sensibility and vitality tests for diagnosing pulpal health in permanent teeth: a critical review. *International Endodontic Journal*, 50(2), 135–142. doi:10.1111/iej.12611.
 18. Hori A, Poureslami HR, Parirokh M, Mirzazadeh A, Abbott P. The ability of pulp sensibility tests to evaluate the pulp status in primary teeth. *Int J Paediatr Dent.* 2011 Nov;21(6):441-5. <https://doi.org/10.1111/j.1365-263X.2011.01147.x>.
 19. Sooratgar A, Ahmadi Z, Asadi Y, Dibaji F, Shamshiri AR, Afkhami F. Evaluation of secondary thermal hyperalgesia resulting from pulpal inflammation in patients with symptomatic irreversible pulpitis. *J Endod.* 2021 Jun;47(6):902-5. <https://doi.org/10.1016/j.joen.2021.02.010>.
 20. Weissheimer T, Só BB, Pradebon MC, Figueiredo JA, Martins MD, Só MV. Head and neck radiotherapy effects on the dental pulp vitality and response to sensitivity tests: a systematic review with meta-analysis. *Int Endod J.* 2022 Jun;55(6):563-78. <https://doi.org/10.1111/iej.13726>.
 21. Kataoka SH, Setzer FC, Gondim-Junior E, Pessoa OF, Gavini G, Caldeira CL. Pulp vitality in patients with intraoral and oropharyngeal malignant tumors undergoing radiation therapy assessed by pulse oximetry. *J Endod.* 2011 Sep;37(9):1197-200. <https://doi.org/10.1016/j.joen.2011.05.038>.
 22. Faria KM, Brandão TB, Ribeiro AC, Vasconcellos AF, Carvalho IT, Arruda FF, et al. Micromorphology of the dental pulp is highly preserved in cancer patients who underwent head and neck radiotherapy. *J Endod.* 2014 Oct;40(10):1553-9. <https://doi.org/10.1016/j.joen.2014.07.006>.
 23. Gopikrishna, V., Tinagupta, K., Kandaswamy, D. Evaluation of Efficacy of a New Custom-Made Pulse Oximeter Dental Probe in Comparison With the Electrical and Thermal Tests for Assessing Pulp Vitality. *Journal of Endodontics.* 2007a; 33(4):411– 414. doi: 10.1016/j.joen.2006.12.003.
 24. Radhakrishnan S, Munshi AK, Hegde AM. Pulse oximetry: a diagnostic instrument in pulpal vitality testing. *J Clin Pediatr Dent* 2002; 26(2):141–5. 33. doi: 10.17796/jcpd.26.2.2j25008jg6u86236.
 25. Estrela C, Serpa GC, Alencar AH, Bruno KF, Barletta FB, Felipe WT, et al. Oxygen Saturation in the Dental Pulp of Maxillary Premolars in Different Age Groups - Part 1. *Braz Dent J.* 2017;28(5):573-7. <https://doi.org/10.1590/0103-6440201701660>.
 26. Estrela C, Oliveira KS, Alencar AH, Barletta FB, Estrela CR, Felipe WT. Oxygen Saturation in the Dental Pulp of Maxillary and Mandibular Molars - Part 2. *Braz Dent J.* 2017;28(6):704-9. <https://doi.org/10.1590/0103-6440201701447>.

- 27.** Daveswar SR, Kapoor SV, Daveswar MR. A clinical study determining pulp vitality in oropharyngeal cancer patients undergoing radiotherapy using diagnostic tool-pulse oximetry. *Curr Health Sci J.* 2021;47(1):5-9. <https://doi.org/10.12865/CHSJ.47.01.01>.
- 28.** Antic S, Markovic-Vasiljkovic B, Dzeletovic B, Jelovac DB, Kuzmanovic-Pficer J. Assessment of radiotherapy effects on the blood flow in gingiva and dental pulp - a laser Doppler flowmetry study. *J Appl Oral Sci.* 2022 Dec;30:e20220329. <https://doi.org/10.1590/1678-7757-2022-0329>.
- 29.** Havelek R, Soukup T, Čmielová J, Seifrtová M, Suchánek J, Vávrová J, et al. Ionizing radiation induces senescence and differentiation of human dental pulp stem cells. *Folia Biol (Praha).* 2013;59(5):188-97. PMID: 24280141
- 30.** Madani ZS, Azarakhsh S, Shakib PA, Karimi M. Histopathological changes in dental pulp of rats following radiotherapy. *Dent Res J (Isfahan).* 2017;14(1):19-24. <https://doi.org/10.4103/1735-3327.201139>.
- 31.** Miyauchi M, Takata T, Ito H, Ogawa I, Kobayashi J, Nikai H, Ijuhin N. Immunohistochemical demonstration of prostaglandins E2, F2 alpha, and 6-keto-prostaglandin F1 alpha in rat dental pulp with experimentally induced inflammation. *J Endod.* 1996 Nov;22(11):600-2. doi: 10.1016/S0099-2399(96)80029-X. PMID: 9198415.
- 32.** Artese L, Rubini C, Ferrero G, Fioroni M, Santinelli A, Piattelli A. Vascular endothelial growth factor (VEGF) expression in healthy and inflamed human dental pulps. *J EnKaeser PS, Deng L, Wang Y, Dulubova I, Liu X, Rizo J, Südhof TC.* RIM proteins tether Ca²⁺ channels to presynaptic active zones via a direct PDZ-domain interaction. *Cell.* 2011 Jan 21;144(2):282-95. doi: 10.1016/j.cell.2010.12.029. PMID: 21241895; PMCID: PMC3063406.
- 33.** Lang M, Moradi-Chameh H, Zahid T, Gane J, Wu C, Valiante T, Zhang L. Regulating hippocampal hyperexcitability through GABAB Receptors. *Physiol Rep.* 2014 Apr 22;2(4):e00278. doi: 10.14814/phy2.278. PMID: 24771688; PMCID: PMC4001873.
- 34.** Lee WH, Sonntag WE, Mitschelen M, Yan H, Lee YW. Irradiation induces regionally specific alterations in pro-inflammatory environments in rat brain. *Int J Radiat Biol.* 2010 Feb;86(2):132-44. doi: 10.3109/09553000903419346. PMID: 20148699; PMCID: PMC2827151.
- 35.** Girault JA, Greengard P. The neurobiology of dopamine signaling. *Arch Neurol.* 2004 May;61(5):641-4. doi: 10.1001/archneur.61.5.641. Erratum in: *Arch Neurol.* 2004 Aug;61(8):1180. PMID: 15148138.

- 36.** Kataoka SH, Setzer FC, Fregnani ER, Pessoa OF, Gondim E Jr, Caldeira CL. Effects of 3-dimensional conformal or intensity-modulated radiotherapy on dental pulp sensitivity during and after the treatment of oral or oropharyngeal malignancies. *J Endod.* 2012 Feb;38(2):148-52. doi: 10.1016/j.joen.2011.09.022. Epub 2011 Nov 14. PMID: 22244627.

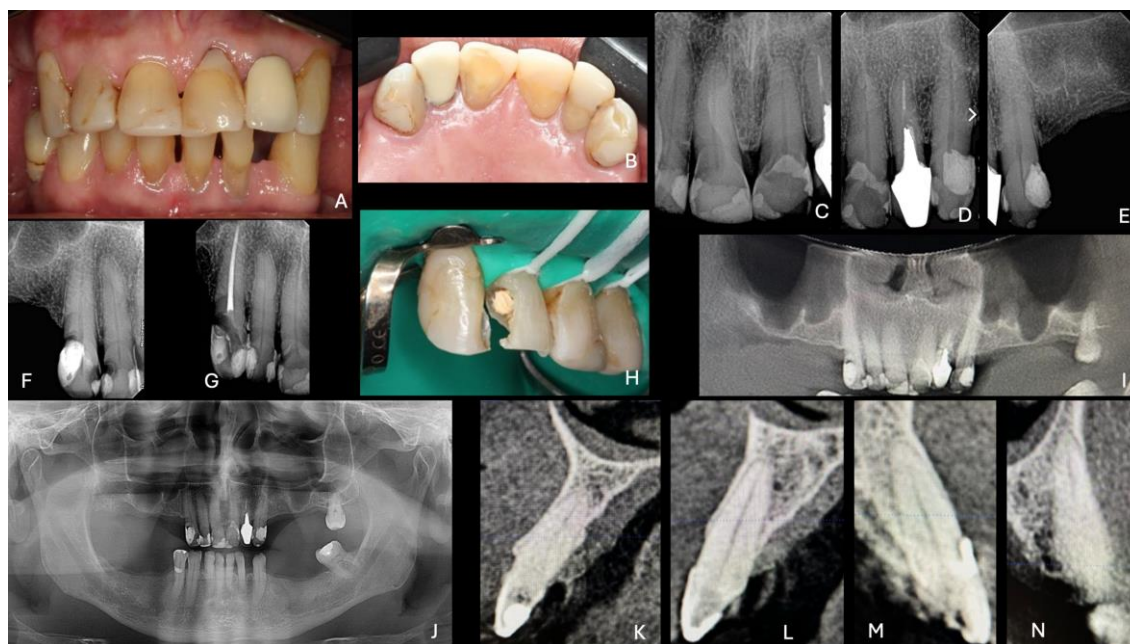


Figure 1. Images 6 months after radiotherapy treatment: A. Frontal intraoral view; B. Occlusal view of the anterior teeth; C. Periapical radiograph of teeth 11 and 21; D. Periapical radiograph of teeth 21, 22 and 23; E. Periapical radiograph of tooth 23; F. Periapical radiograph of teeth 13 and 12; G. Periapical radiograph after endodontic treatment of tooth 13; H. Photograph of tooth 12 after placement of calcium hydroxide cement before restoration with composite resin; I. Tomographic image of the maxilla; J. Panoramic radiography; K. Tomographic image - sagittal section 12; L. Tomographic image – sagittal section 11; M. Tomographic image - sagittal section 21; N. Tomographic image – sagittal section 23.

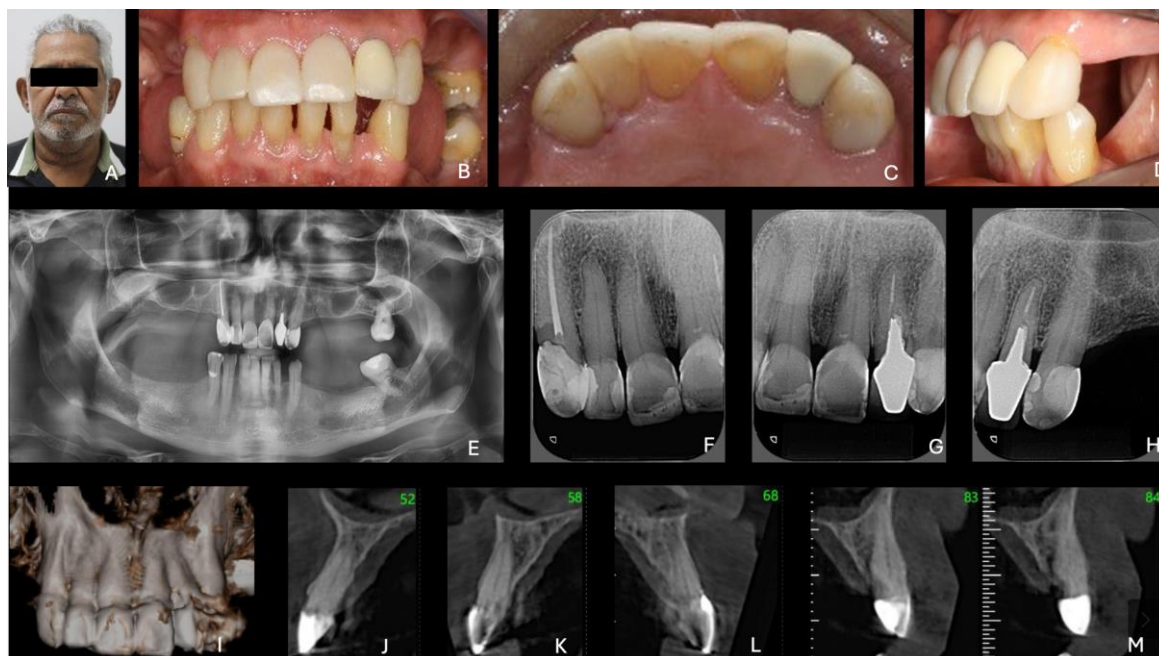


Figure 2. Images 12 months after radiotherapy treatment: A. Frontal extraoral view; B. Frontal intraoral view of the anterior teeth; C. Occlusal intraoral view of the anterior teeth; D. Left lateral intraoral view of the anterior teeth; E. Panoramic radiograph; F. Periapical radiograph of teeth 13, 12 and 11; G. Periapical radiograph of teeth 11, 21 and 22; H. Periapical radiograph of teeth 22 and 23; I. Tomographic reconstruction of the maxilla; J. Tomographic image - sagittal section 12; K. Tomographic image - sagittal section 11; L. Tomographic image - sagittal section 21; M. Tomographic image - sagittal section 23.

CONCLUSÃO

3. CONCLUSÃO

Nas condições deste estudo, conclui-se que:

1. A radiação ionizante utilizada durante radioterapia em pacientes com câncer em região de cabeça e pescoço alterou a composição química e a dureza da dentina intrarradicular, principalmente nas regiões dos terços cervical e médio;
2. A reabilitação dentária de dentes tratados endodonticamente com severa perda de estrutura da coroa utilizando pinos de fibra de vidro cimentados adesivamente com cimento autoadesivo e reconstrução com resina composta mostrou resultados promissores, de acordo com os achados clínicos avaliados pelos critérios FDI, análise por imagem e ausência de decimentação de pinos de fibra de vidro no período avaliado;
3. A radiação ionizante modificou temporariamente a condição pulpar e a resposta ao teste de vitalidade pulpar ao frio em paciente irradiado em região de cabeça e pescoço. Seis meses após a radioterapia, os dentes apresentaram resposta negativa ao teste de vitalidade pulpar térmico a frio. No entanto, 12 meses após o tratamento, alguns dentes exibiram retorno da resposta de vitalidade pulpar.

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REFERÊNCIAS

5. REFERÊNCIAS

1. Moore C, McLister C, Cardwell C, O'Neill C, Donnelly M, & McKenna, G. Dental caries following radiotherapy for head and neck cancer: A systematic review. *Oral Oncology Journal*. 2020; 100, Article 104484. <https://doi.org/10.1016/j.oraloncology.2019.104484>.
2. Fang, Y. Z., Yang, S., & Wu, G. Free radicals, antioxidants, and nutrition. *Nutrition*. 2002; 18,872–879. [https://doi.org/10.1016/S0899-9007\(02\)00916-4](https://doi.org/10.1016/S0899-9007(02)00916-4).
3. Gonçalves, L. M. N., Palma-Dibb, R. G., Paula-Silva, F. W. G., de Oliveira, H. F., NelsonFilho, P., da Silva, L. A. B., et al. Radiation therapy alters microhardness and microstructure of enamel and dentin of permanent human

- teeth. *Journal of Dentistry*. 2014; 42:986–992. <https://doi.org/10.1016/j.jdent.2014.05.011>.
4. Qing, P., Huang, S., Gao, S., Qian, L., & Yu, H. Effect of gamma irradiation on the wear behavior of human tooth enamel. *Scientific Reports*. 2015; 5:1–9. <https://doi.org/10.1038/srep11568>.
 5. Reed, R., Xu, C., Liu, Y., Gorski, J. P., Wang, Y., & Walker, M. P. Radiotherapy effect on nano-mechanical properties and chemical composition of enamel and dentine. *Archives of Oral Biology*. 2015; 60:690–697. <https://doi.org/10.1016/j.archoralbio.2015.02.020>.
 6. Rodrigues RB., Soares CJ., Junior PCS., Lara VC., Arana-Chavez VE., Novais VR. Influence of radiotherapy on the dentin properties and bond strength. *Clin Oral Investig*. 2018; 22(2):875-883. DOI: 10.1007/s00784-017-2165-4.
 7. Lu, H., Zhao, Q., Guo, J., Zeng, B., Yu, X., Yu, D., et al. Direct radiation-induced effects on dental hard tissue. *Physics and Imaging in Radiation Oncology*. 2019; 14, Article 5. <https://doi.org/10.1186/s13014-019-1208-1>.
 8. Miranda, R. R., Ribeiro, T. E., Silva, E. L. C. D., Simamoto Júnior, P. C., Soares, C. J., & Novais, V. R. Effects of fractionation and ionizing radiation dose on the chemical composition and microhardness of enamel. *Archives of Oral Biology*. 2021; 121, Article 104959. <https://doi.org/10.1016/j.archoralbio.2020.104959>.
 9. Douchy, L., Gauthier, R., Abouelleil-Sayed, H., Colon, P., Grosogeat, B., & Bosco, J. The effect of therapeutic radiation on dental enamel and dentin: A systematic review. *Dental Materials*; 2022; 12. <https://doi.org/10.1016/j.dental.2022.04.014>.
 10. Velo, M.M.d.A.C., Farha, A.L.H., da Silva Santos, P.S. *et al* .Radiotherapy alters the composition, structural and mechanical properties of root dentin in vitro. *Clin Oral Invest*. 2018; 22:2871–2878. <https://doi.org/10.1007/s00784-018-2373-6>.
 11. Campi LB, Lopes FC, Soares LES, de Queiroz AM, de Oliveira HF, Saquy PC, de Sousa-Neto MD. Effect of radiotherapy on the chemical composition of root dentin. *Head Neck*. 2019 Jan; 41(1):162-169. doi: 10.1002/hed.25493. Epub 2018 Dec 15. PMID: 30552849.
 12. Miranda, R. R., Silva, A. C. A., Dantas, N. O., Soares, C. J., & Novais, V. R. Chemical analysis of in vivo–irradiated dentine of head and neck cancer patients by ATR-FTIR and Raman spectroscopy. *Clinical Oral Investigations*. 2019; 23(8), 3351. <https://doi.org/10.1007/s00784-018-2758-6>.

13. Pelloso AM, de Miranda RR, Rossi ME, Bianchini ALB, Marcelino FAS, da Silva ELC, Novais VR. Chemical analysis of irradiated root dentin and its interaction with resin cements. *Clin Oral Investig*. 2022 Jun; 26(6):4315-4325. doi: 10.1007/s00784-022-04395-z.
14. Jawad H, Hodson NA, Nixon PJ. A review of dental treatment of head and neck cancer patients, before, during and after radiotherapy: part 1. *Br Dent J*. 2015; 218(2):65-8. doi: 10.1038/sj.bdj.2015.29.
15. Gupta N., Grewal MS., Gairola M., Grewal S., Ahlawat P. Dental Pulp Status of Posterior Teeth in Patients with Oral and Oropharyngeal Cancer Treated with Radiotherapy: 1-year Follow. *J Endod*. 2018; 44(4):549-554. DOI: 10.1016/j.joen.2017.12.017.
16. Pelloso AM, Rossi ME, Miranda RR, Soares CJ, Novais VR. Radiotherapy in the head and neck region influences the chemical and mechanical properties of intraradicular dentin. *Arch Oral Biol*. 2024; 158:105868. doi: 10.1016/j.archoralbio.2023.105868.
17. Hickel R, Mesinger S, Opdam N, Loomans B, Frankenberger R, Cadenaro M, Burgess J, Peschke A, Heintze SD, Kühnisch J. Revised FDI criteria for evaluating direct and indirect dental restorations-recommendations for its clinical use, interpretation, and reporting. *Clin Oral Investig*. 2023;27(6):2573-2592. doi: 10.1007/s00784-022-04814-1.
18. Ribeiro TE, Novais VR, Estrela C, Santana MLL, Rossi-Fedele G, Decurcio DA. Does radiotherapy treatment alter the pulp condition in patients with head and neck cancer? A systematic review. *Braz Oral Res*. 2023 Jul 28;37:e079. doi: 10.1590/1807-3107bor-2023.vol37.0079. PMID: 37531515.
19. Kataoka SHH., Setzer FC., Gondim-Junior E., Fregnani ER., Moraes CJP., Pessoa OF., Gavini.G., Caldira CL. Late effects of head and neck radiotherapy on pulp vitality assessed by pulse oximetry. *J Endod*. 2016; 42(6):886-9. DOI: 10.1016/j.joen.2016.02.016.

*De acordo com a Norma da FOUFU, baseado nas Normas de Vancouver. Abreviaturas dos periódicos com conformidade com Medline (Pubmed).

ANEXO CEP

6. ANEXO CEP

COMPROVANTE DE ENVIO DO PROJETO

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Efeitos da radioterapia nas propriedades, composição e estrutura da dentina humana

Pesquisador: Veridiana Resende Novais

Versão: 1

CAAE: 60743716.2.0000.5152

Instituição Proponente: Universidade Federal de Uberlândia/ UFU/ MG

DADOS DO COMPROVANTE

Número do Comprovante: 103719/2016

Patrocinador Principal: Financiamento Próprio

Informamos que o projeto Efeitos da radioterapia nas propriedades, composição e estrutura da dentina humana que tem como pesquisador responsável Veridiana Resende Novais, foi recebido para análise ética no CEP Universidade Federal de Uberlândia/MG em 06/10/2016 às 13:42.

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