BJOS
Brazilian Journal of Oral Sciences

Original Article

Volume 22
2023
e238447

Clinical dental management of the head and neck irradiated patient: topics of interest for clinicians

Nuryê Rezende Prisinoto[1], Cariniana Macedo de Alcântara[2], Dhiancarlo Rocha Macedo[3], Meire Coelho Ferreira[4], Daniela Malagoni Fagundes[5], Priscilla Barbosa Ferreira Soares[6]*

[1] MSc student, School of Dentistry, Federal University of Uberlândia (UFU), Uberlândia, MG, Brazil.

[2] Undergraduate student, School of Dentistry, Federal University of Uberlândia (UFU), Uberlândia, MG, Brazil.

[3] PhD student, School of Dentistry, Federal University of Uberlândia (UFU), MG, Brazil.

[4] Professor at Dentistry Department, School of Dentistry, CEUMA University (UNICEUMA), São Luís, Maranhão, Brazil.

[5] PhD student, School of Dentistry, CEUMA University (UNICEUMA), São Luís, MA, Brazil.

[6] Professor of Periodontology and Implantology Department, School of Dentistry, Federal University of Uberlândia (UFU), MG, Brazil.

Corresponding author:
Priscilla Barbosa Ferreira Soares, DDS, Mas, PhD, CEUMA University, School of Dentistry.
Av. Pará, 1720, Bloco 4L, Anexo A, Campos Umuarama
CEP: 38400-902, Uberlândia, Minas Gerais, Brazil.
pbfsoares@yahoo.com.br

Editor: Altair A. Del Bel Cury

Received: Feb 17, 2022
Accepted: Jun 6, 2023

Aim: To discuss important topics regarding the dental procedures performed in patients before, during and after the radiotherapy treatment. The biological effects of ionizing radiation on bone tissue focusing on clinical care will be described. The invasive and not invasive procedures after radiotherapy treatment in the head and neck region will be addressed using scientific evidences to determine the appropriate moment for tooth extractions, periodontal management, and preventive procedures for osteoradionecrosis. **Methods:** Thirty-three studies including original studies and reviews were selected in MEDLINE database (PubMed). No year of publication restriction was applied. Language was restricted to the English, and the following Medical Subject Heading terms were used: radiotherapy, osteoradionecrosis, dental management. Studies of osteoradionecrosis involving clinical management of irradiated patients, with an emphasis on updated guidelines and protocols were selected. **Results:** Care in dental procedures were related about restorative treatment, endodontic treatment, rehabilitation for edentulous regions using prostheses and implants and periodontal procedures before, during and after RTX treatment. **Conclusions:** The dental procedures should and can be performed before, during but also after radiotherapy. However, the clinical procedures should be less invasive as possible. A maintenance plan that reduces the necessity for major and more invasive treatments after radiotherapy is recommended.

Keywords: Head and neck neoplasms. Radiotherapy. Osteoradionecrosis.

Introduction

Radiotherapy (RTX) treatment is widely used to treat various types of head and neck cancers[1]. The purpose of RTX is to control the growth or elimination of the tumor[1], reducing the possibility of recurrence and improving the patient's quality of life[1]. RTX treatment is indicated as a palliative protocol of incurable cancers[1]. Despite of the benefits of this therapy, some patients frequently are involved with adverse effects caused by ionizing radiation[2,3]. The main complications associated with RTX are: mucositis, xerostomia, changes in salivary quality and quantity, opportunistic infections, tissue fibrosis, sensory dysfunctions such as dysgeusia, increased periodontal disease progression, caries and osteoradionecrosis (ORN)[4]. These intercurrences can have acute manifestation, during the treatment, or chronic manifestation after the completion of the treatment[4].

The clinical characteristic of ORN is bone necrosis due to hypoxia, hypovascularization and hypocellularity[5], with loss of mucosal integrity, associated or not with oral environment bone exposure[2]. The ORN is the most serious adverse effect of RTX, compromising the tissue integrity and health of the oral structures. The ORN incidence ranges from 5 to 30% of patients who have undergone head and neck RTX[3]. The incidence of RTX has decreased with the use of the most modern radiation techniques[3].

Several risk factors are associated with the development of the ORN, such as smoking, periodontal disease, alcohol abuse, intensity and duration of radiation[2]. Controlling the risk factors is important to minimize the development of ORN. The approaches proposed for the treatment of ORN involve non-invasive techniques such as maintaining the quality of oral hygiene, the use of antibiotic therapy, and also extensive surgical procedures to remove the necrotic bone[2]. The high uncertainty rate of the infection control is a factor that must be considered for choosing the ideal treatment[2].

The knowledge about the manifestations caused by ionizing radiation in the oral cavity has great importance for clinicians. Many professionals still have doubts regarding the treatment planning and the management of patients involved with RTX. Despite some other reviews have been focused on the management of the head and neck cancer patients[6,7], the continuous update of the information about the specific care about the preventive and therapeutic procedures in patients' wit history of head and neck cancer is of a paramount importance. Therefore, this study aimed to describe and clarify the dental procedures performed by clinicians in cancer patients before, during and after RTX treatment.

Materials and methods

Thirty-three studies were included in this narrative review. twenty-one these studies were original researches while twelve were reviews. The reviews of literature were no excluded due to the informative nature of this review, approaching different protocols of care in the head and neck irradiated patient. These studies were searched in the MEDLINE databases (PubMed). All selected through the focus on the management of irradiated patients in the head and neck region. No pub-

lication year restriction was applied. The language was restricted to English, and the following Medical Subject Heading terms were used: radiotherapy, osteoradionecrosis, dental management. Studies on osteoradionecrosis involving clinical management of irradiated patients, with an emphasis on updated guidelines and protocols, were selected.

Dental procedures before and during RTX treatment

Before starting RXT, the professional must perform all necessary adequacy of the oral environment[1]. Caries lesions treatment, subgingival scaling, endodontic treatments or tooth extraction that could be the focus of infection should be performed[2]. These procedures should be performed at least two weeks before to start the RTX treatment[2]. The prevention of ORN is based on elimination of the oral cavity infectious conditions at the pre-RXT phase, as well as to prevent the invasive procedures during and after RXT treatment[8]. Monitoring the quality of oral hygiene should be also always performed, since the development of ORN is also associated with poor oral hygiene[8].

During the irradiation period, mucositis, opportunistic infections such as candidiasis, salivary gland dysfunctions such as xerostomia and taste alterations are frequently reported by patients[9]. During the RTX, invasive dental procedures are not recommended[2]. Prior monitoring the patient oral conditions should be performed[2], except in cases the occurrence of an emergency, then the invasive procedures are necessary for maintaining the patient's safety and health.

Dental procedures after RTX treatment

Post- RXT patients may have chronic complications such as ORN, xerostomia and trismus[9]. The irradiated patients may need dental care requiring the performance of various dental procedures, such as tooth restorations, endodontics, rehabilitation, among others[10,11]. It is important that clinicians understand the consequences of RTX on the mucosa, bone tissue and dental tissue to prevent the installation of ORN and failure of clinical procedures[12].

Ionizing radiation produces hypoxia, hypocellularity and hypovascularization that can alter the regenerative potential of the soft and hard tissues[2,13,14]. Changes in tooth and bone structure can occur due to degradations in amine components that can mechanically alter enamel[15,16], dentin[12], and bones[14,15,17]. The effect of ionizating radiaton on the salivary flow and the xerostomia reduce the protection of this fluid against pathogens and enhance the friction on the mucosa during the oral chewing that could be the trigger for the occurrence of the mucositis lesions[18].

Extractions

Post-RTX extraction is an important risk factors for the development of the ORN[19], then this procedure should be avoided during this period[3]. A safety period for the development of the ORN is inconclusive[3,12]. The tooth extractions performed during post-RTX can result on ORN, due the invasive procedure in bone and mucosa tissues, which can compromise the microarchitecture and vascularization[3,5,12,19].

A retrospective study evaluated 32 patients with tooth extraction after RTX and showed the ORN in 12.1% (9 patients)[19]. The patients with ORN received higher radiation dose (62.0 Gy vs. 37.4 Gy) and longer treatment time until extraction (41.2 months vs. 28.2 months) than the groups of patients without ORN. The recent systematic demonstrates that the presence of risk factors such as smoking, radiation dose and duration of treatment are more predictable aspects in decision-making when performing dental extractions than the time after RTX[3].

The possibility of occurrence of ORN after tooth extraction is a possible and uncertain complication. If necessary, the extraction should be performed less traumatically possible, avoiding large flaps and osteotomies in order to improve the healing process[2]. Adjunct therapies, such as photobiomodulation, ozonetherapy, PENTOCLO protocol, hyperbaric chambers, may also be indicated, as early intervention may reduce the risk of ORN[20].

Restorative treatment

In irradiated patients increased the risk of developing dental carious lesions due to multiple factors[21,22]. The development of carious lesions after RTX treatment can occur mainly from three months after irradiation and can lead to a severe oral health impact[15,22,23]. These effects can occur due to the degradation of the organic components of dentin and enamel, which stimulate the increasing of its rigidity, making less efficient to support occlusal forces, which leads to the tooth wear[23,24]. The reduction or qualitative alteration of salivary flow turns the patients as a greater risk for developing dental caries due the limited pH buffering function promoted by saliva, as well as the dryness of the oral mucosa that makes oral hygiene procedures more uncomfortable[18,24].

The rapid progression of the carious lesions on enamel and dentin and the structural substrate changes make the restorative protocols a major challenge due the poorly adhesive interaction with the dental substrate[12,24,25]. It has been indicated the use of the neutral fluor application periodically[23,26]. In patients with xerostomia and high risk of radiation carious lesions and poor adherence to preventive fluoride therapy, the use of conventional and resin modified glass ionomer cement are more effective in protecting recurrent carious lesions[10].

Surgical and non-surgical periodontal treatment

Periodontal disease occurs due to an imbalance between the periodontal microbiota and the host response, and the process of oral dysbiosis may be responsible in part for the disease progression[8]. RTX can be an important agent for periodontal microbiota dysbiosis due to reduced salivary flow, which is associated with less efficient oral hygiene[27]. RTX induced fibrotic effects on connective tissues make periodontal tissues less competent in regenerative processes due to reduced oxygenation found especially in terminal-type circulation[28]. These effects together increase the host's susceptibility to present more aggressive periodontal disease, increasing the risk of tooth loss after RTX treatment[29].

Due to the risks of ORN after tooth extraction, a personalized treatment and maintenance plan must be indicated considering the periodontal health status and systemic conditions pre-RXT[8]. The treatments must be completed as soon as possible before RTX, being the full-mouth scaling technique is indicated[27,28]. Periodontal therapy for head and neck cancer implemented before, during and after treatments results in a significant improvement on periodontal health, but this therapy should be maintained, otherwise periodontal disease continues its progression[8,28].

Endodontic treatment

Due to the increased carious lesions activity in patients after RTX, endodontic treatment should be necessary to avoids more aggressive procedures such as extraction[11,21]. However, some factors such as the reduction of the dental pulp oxygenation the structural tooth fragilization can complicate the diagnosis and reduce the endodontic treatment success[11,21]. Pulp oxygenation levels are reduced after 4-6 months, which can impair pulp diagnosis by promoting a negative sensitivity response in vital pulps and directing unnecessary endodontic interventions[21]. If pulp exposure is present, 6-12 months should be performed, due the transitory loss of pulp sensitivity caused by RTX[21]. The endodontic treatment associated with RTX, can increase the tooth structural weakening[21]. Resin composite restorations are recommended to direct restorative material for restoring the endodontically treated teeth, strongly avoiding the use of the amalgam[30]. It is also important and recommended to replace amalgam restorations prior to RTX treatment[31].

Rehabilitation for edentulous regions using prostheses and implants

Most irradiated patients mainly seek treatment for edentulous regions, usually as a result of multiple tooth extractions performed before RTX treatment[12]. Oral rehabilitation is important to improve the patient's quality of life[31]. It is essential that the clinicians understand the procedures that should be avoided in this post-radiation period[32]. Treatments with partial or complete dentures must be carefully performed. The patient follow-up is essential so mismatched dentures can cause damage to the mucosa can generate trauma that predisposes ORN[31,33].

It is not well established the safer rehabilitation procedure for post- RTX patients[32]. When fixed prostheses are indicated, it should be taking in consideration that the tooth substrate after the RTX become more fragile, reducing the predictability of this treatment[12]. Another alternative for oral rehabilitation is the use of dental implants supported prostheses without interfering with compromised mucous membranes and teeth[32,33]. The installation of implants prior to RTX is safer procedure with high success and survival levels[33]. The installation of implants after the RTX period present a slightly higher level of complication compared with the implants installed in the general population[32]. The innovations on macrostructure and microstructure implants surface, and on the implant installation techniques guided by surgery without flap opening, can make the rehabilitation of post-radiotherapy patients increasingly safer and more predictable, but this clinical procedures still requires further investigations.

Discussion

The treatment of head and neck cancer is an extremely challenging condition for maintain the patient's quality of life. The patients tend to resist to the highly aggressive treatments such as extensive surgery to remove the tumor, the RTX protocol, and in many situations to perform multiple tooth extractions prior to the RTX[3]. During and after the period of active treatment, therapeutic planning aiming proper oral rehabilitation is necessary in order to limit the acute and chronic damage caused by cancer treatment[2]. It is important to recognize that the effects of RTX are cumulative, and the indication of the dental procedures must consider the limitations imposed by the alterations on the dental and bone caused by irradiation, avoiding as much as possible the occurrence of ORN.

To avoid this complication, has been suggested not performing dental extraction due the ORN[19]. Bone tissue intervention should ideally be performed before RTX[3]. This indication is based on the progressive process of connective tissue fibrosis that reduces the vascularization, cellularity and oxygenation of oral tissues, especially bone tissue, which can impair the repair processes[5,12,13,28]. The bone tissue has the slower regenerative potential than soft tissues[2,5,14,28]. During the healing phase, especially the post-extraction alveolar repair occurred by second intention, makes this tissue more susceptible to contamination and subsequent development of necrotic lesions, which are difficult to treat[2].

There is an important relationship between the occurrence of cancer in the head and neck region and poor periodontal conditions, since the risk factors are shared[27,29]. It is expected that patients indicated for RTX treatment may have more severe and active periodontal disease than the general population[29]. Periodontal treatment after RTX should be performed as quickly and less aggressively as possible, avoiding surgical procedures to access root surfaces[8,29]. Supportive periodontal therapy should be performed at least every 3 months to prevent disease progression that the risk of tooth loss[4]. It is recommended that teeth with a questionable periodontal prognosis should be removed at least 14 days prior to initiation of RTX[28].

If the treatment plan and preventive procedures before RTX are indicated for the teeth maintenance. Special attention is essential due the changes in the protein portion on the dentin, enamel and at the cementoenamel junction substrate. Associated with the salivary flow reduction the developing radiation carious lesions is increased[15,22]. The adhesive systems efficiency is reduced in forming prober hybrid layer to dentin substrate and the different restorative materials[12]. Thus, restorative materials that allow the continuous release the fluoride, such as conventional or resin modified glass ionomer cements should be chosen, reducing the recurrent carious lesions, and the dependence on the bonding interface promoted by adhesive systems[12]. More extensive carious lesions with pulp involvement may indicate endodontic therapy, that will further weaken the tooth structure affected by RTX[34].

The dosage used and the time elapsed of the RTX should be taken in consideration during the planning of the rehabilitation of the edentulous areas[28]. It has been described that muco-supported prostheses must be well adapted to avoid trauma to the mucosa, as this tissue is also fragile and can more easily lose its integrity and

expose the adjacent bone tissue[31]. The denture-supported dentures planning must consider the quality of the remaining abutment teeth, avoiding involving teeth with large restorations with endodontic treatment as abutments[11,21]. Teeth with a history of periodontal disease are more susceptible to disease progression after RTX and should also be avoided as support for protheses[4].

The security of the implant placement in patients after the RTX are inconclusive. It has been described that the rehabilitation with dental implants has been indicated as a good alternative to rehabilitate patients after RTX and has shown relatively good levels of clinical survival[33]. It has been also showed that the bone tissue surgery may present higher risk factor for the ORN installation[34]. Indeed, the myriad of protocols of RTX impairs a properly documentation regarding the safety for implants placement in these patients[19].

Technological advances may improve the outcomes of the oral treatment in the RTX patients. The advances in the mechanical of the restorative materials associated with adhesive procedures, and preventive protocols may improve the treatment complication related with the carious lesions[11,30]. The implants design and microstructure advantages, as well as the use of less traumatic surgeries may enhance the oral rehabilitation predictability[35]. In addition, the dental therapy may become more safety as much the RTX protocols become more focused on injuries[33]. The dental treatment after RTX is possible to be performed, but they should be less invasive as possible.

Conclusion

In conclusion, the dental procedures before, during and after RTX should be performed, however they should be always less invasive as possible. However, the type complexity of the treatment is patient and moment dependent. A maintenance plan performed before, during and after RTX is strongly recommended to reduce the necessity for major and more invasive treatments after radiotherapy.

Acknowledgements

This study was supported by the research funding agencies FAPEMIG, CNPq and CAPES.

Conflict of interest

None.

Authors Contribution

All authors actively participated in the discussion of the manuscript findings, reviewed, and approved the final version of this manuscript.

Data availability

Datasets related to this article will be available upon request to the corresponding author.

References

1. Spijkervet FKL, Brennan MT, Peterson DE, Witjes MJH, Vissink A. Research frontiers in oral toxicities of cancer therapies: osteoradionecrosis of the jaws. J Natl Cancer Inst Monogr. 2019 Aug;2019(53):lgz006. doi: 10.1093/jncimonographs/lgz006.
2. 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 2018 Feb;68(1):22-30. doi: 10.1111/idj.12318.
3. Beaumont S, Bhatia N, McDowell L, Fua T, McCullough M, Celentano A, et al. Timing of dental extractions in patients undergoing radiotherapy and the incidence of osteoradionecrosis: a systematic review and meta-analysis. Br J Oral Maxillofac Surg. 2021 Jun;59(5):511-23. doi: 10.1016/j.bjoms.2020.10.006.
4. Sroussi HY, Epstein JB, Bensadoun RJ, Saunders DP, Lalla RV, Migliorati CA, et al. Common oral complications of head and neck cancer radiation therapy: mucositis, infections, saliva change, fibrosis, sensory dysfunctions, dental caries, periodontal disease, and osteoradionecrosis. Cancer Med. 2017 Dec;6(12):2918-31. doi: 10.1002/cam4.1221.
5. Soares PBF, Soares CJ, Limirio PHJO, de Jesus RNR, Dechichi P, Spin-Neto R, et al. Effect of ionizing radiation after-therapy interval on bone: histomorphometric and biomechanical characteristics. Clin Oral Investig. 2019 Jun;23(6):2785-93. doi: 10.1007/s00784-018-2724-3.
6. Beech N, Robinson S, Porceddu S, Batstone M. Dental management of patients irradiated for head and neck cancer. Aust Dent J. 2014 Mar;59(1):20-8. doi: 10.1111/adj.12134.
7. 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 Jan;218(2):65-8. doi: 10.1038/sj.bdj.2015.28.
8. Gaetti-Jardim Jr E, Jardim ECG, Schweitzer CM, da Silva JCL, Oliveira MM, Masocatto DC, et al. Supragingival and subgingival microbiota from patients with poor oral hygiene submitted to radiotherapy for head and neck cancer treatment. Arch Oral Biol. 2018 Jun;90:45-52. doi: 10.1016/j.archoralbio.2018.01.003.
9. Mercadante V, Al Hamad A, Lodi G, Porter S, Fedele S. Interventions for the management of radiotherapy-induced xerostomia and hyposalivation: A systematic review and meta-analysis. Oral Oncol. 2017 Mar;66:64-74. doi: 10.1016/j.oraloncology.2016.12.031.
10. Santin GC, Queiroz AM, Palma-Dibb RG, Oliveira HF, Nelson Filho P, Romano FL. Glass Ionomer Cements can be used for Bonding Orthodontic Brackets After Cancer Radiation Treatment? Braz Dent J. 2018 Mar-Apr;29(2):128-32. doi: 10.1590/0103-6440201801436.
11. Castagnola R, Minciacchi I, Rupe C, Marigo L, Grande NM, Contaldo M, et al. The outcome of primary root canal treatment in postirradiated patients: a case series. J Endod. 2020 Apr;46(4):551-6. doi: 10.1016/j.joen.2019.12.005.
12. Munoz MA, Garin-Correa C, Gonzalez-Arriagada W, Quintela Davila X, Haberle P, Bedran-Russo A, et al. The adverse effects of radiotherapy on the structure of dental hard tissues and longevity of dental restoration. Int J Radiat Biol. 2020 Jul;96(7):910-8. doi: 10.1080/09553002.2020.1741718.
13. Mendes EM, Irie MS, Rabelo GD, Borges JS, Dechichi P, Diniz RS, et al. Effects of ionizing radiation on woven bone: influence on the osteocyte lacunar network, collagen maturation, and microarchitecture. Clin Oral Investig. 2020 Aug;24(8):2763-71. doi: 10.1007/s00784-019-03138-x.
14. Borges JS, Rabelo GD, Irie MS, Paz JLC, Spin-Neto R, Soares PBF. Cortical bone modifications after radiotherapy: cortex porosity and osteonal changes evaluated over time. Braz Dent J. 2021 Jan-Feb;32(1):9-15. doi: 10.1590/0103-6440202103384.

15. de Miranda RR, Silva ACA, Dantas NO, Soares CJ, Novais VR. Chemical analysis of in vivo-irradiated dentine of head and neck cancer patients by ATR-FTIR and Raman spectroscopy. Clin Oral Investig. 2019 Aug;23(8):3351-8. doi: 10.1007/s00784-018-2758-6.

16. Miranda RR, Ribeiro TE, Silva E, Simamoto Junior 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.

17. Limirio P, Soares PBF, Emi ETP, Lopes CCA, Rocha FS, Batista JD, et al. Ionizing radiation and bone quality: time-dependent effects. Radiat Oncol. 2019 Jan;14(1):15. doi: 10.1186/s13014-019-1219-y.

18. Ribeiro LN, Lima MH, Carvalho AT, Albuquerque RF, Leao JC, Silva IH. Evaluation of the salivary function of patients in treatment with radiotherapy for head and neck cancer submitted to photobiomodulation. Med Oral Patol Oral Cir Bucal. 2021 Jan;26(1):e14-e20. doi: 10.4317/medoral.23912.

19. Saito I, Hasegawa T, Kawashita Y, Kato S, Yamada SI, Kojima Y, et al. Association between dental extraction after radiotherapy and osteoradionecrosis: A multi-centre retrospective study. Oral Dis. 2022 May;28(4):1181-7. doi: 10.1111/odi.13826.

20. Nabil S, Samman N. Incidence and prevention of osteoradionecrosis after dental extraction in irradiated patients: a systematic review. Int J Oral Maxillofac Surg. 2011 Mar;40(3):229-43. doi: 10.1016/j.ijom.2010.10.005.

21. 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-up. J Endod. 2018 Apr;44(4):549-54. doi: 10.1016/j.joen.2017.12.017.

22. 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 Oncol. 2020 Jan;100:104484. doi: 10.1016/j.oraloncology.2019.104484.

23. Palmier NR, Migliorati CA, Prado-Ribeiro AC, de Oliveira MCQ, Vechiato Filho AJ, de Goes MF, et al. Radiation-related caries: current diagnostic, prognostic, and management paradigms. Oral Surg Oral Med Oral Pathol Oral Radiol. 2020 Jul;130(1):52-62. doi: 10.1016/j.oooo.2020.04.003.

24. 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 Mar;22(2):875-83. doi: 10.1007/s00784-017-2165-4.

25. Naves LZ, Novais VR, Armstrong SR, Correr-Sobrinho L, Soares CJ. Effect of gamma radiation on bonding to human enamel and dentin. Support Care Cancer. 2012 Nov;20(11):2873-8. doi: 10.1007/s00520-012-1414-y.

26. Lopes CCA, Soares CJ, Lara VC, Arana-Chavez VE, Soares PB, Novais VR. Effect of fluoride application during radiotherapy on enamel demineralization. J Appl Oral Sci. 2018 Dec;27:e20180044. doi: 10.1590/1678-7757-2018-0044.

27. Jung YS, Park EY, Sohn HO. Oral health status and oral health-related quality of life according to presence or absence of mucositis in head and neck cancer patients. J Cancer Prev. 2019 Mar;24(1):43-7. doi: 10.15430/JCP.2019.24.1.43.

28. Irie MS, Mendes EM, Borges JS, Osuna LG, Rabelo GD, Soares PB. Periodontal therapy for patients before and after radiotherapy: A review of the literature and topics of interest for clinicians. Med Oral Patol Oral Cir Bucal. 2018 Sep;23(5):e524-30. doi: 10.4317/medoral.22474.

29. Pockpa AD, Soueidan A, Louis P, Coulibaly NT, Badran Z, Struillou X. Twenty years of full-mouth disinfection: the past, the present and the future. Open Dent J. 2018 May;12:435-42. doi: 10.2174/1874210601812010435.

30. Soares CJ, Roscoe MG, Castro CG, Santana FR, Raposo LH, Quagliatto PS, et al. Effect of gamma irradiation and restorative material on the biomechanical behaviour of root filled premolars. Int Endod J. 2011 Nov;44(11):1047-54. doi: 10.1111/j.1365-2591.2011.01920.x.

31. Vosselman N, Alberga J, Witjes MHJ, Raghoebar GM, Reintsema H, Vissink A, et al. Prosthodontic rehabilitation of head and neck cancer patients-Challenges and new developments. Oral Dis. 2021 Jan;27(1):64-72. doi: 10.1111/odi.13374.

32. Petrovic I, Rosen EB, Matros E, Huryn JM, Shah JP. Oral rehabilitation of the cancer patient: A formidable challenge. J Surg Oncol. 2018 Jun;117(8):1729-35. doi: 10.1002/jso.25075.

33. Sandoval ML, Rosen EB, Robert AJ, Nelson JA, Matros E, Gelblum DY. Immediate dental implants in fibula free flaps to reconstruct the mandible: a pilot study of the short-term effects on radiotherapy for patients with head and neck cancer. Clin Implant Dent Relat Res. 2020 Feb;22(1):91-5. doi: 10.1111/cid.12870.

34. Novais VR, Soares PB, Guimarães CM, Schliebe LR, Braga SS, Soares CJ. Effect of gamma radiation and endodontic treatment on mechanical properties of human and bovine root dentin. Braz Dent J. 2016 Oct-Dec;27(6):670-4. doi: 10.1590/0103-6440201601267.

35. Romanos GE, Delgado-Ruiz R, Sculean A. Concepts for prevention of complications in implant therapy. Periodontol 2000. 2019 Oct;81(1):7-17. doi: 10.1111/prd.12278.