Late Effects of Head and Neck Radiotherapy on Pulp Vitality Assessed by Pulse Oximetry

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Abstract  
Introduction: Radiation therapy (RT) of malignant tumors in the head and neck area may have damaging effects on surrounding tissues. The aim of this investigation was to evaluate the long-term effects of ionizing radiation on pulp vitality by measuring pulp oxygenation levels (%SpO2) in patients with history of RT of intraoral and oropharyngeal tumors 4–6 years after treatment. Methods: In an experimental group RT (n = 90, history of RT) and a control group CON (n = 90, no history of RT), pulp vitality was assessed by measuring %SpO2 by using pulse oximetry and pulp sensitivity by cold thermal testing. All anterior teeth without history of endodontic therapy of the participants in group RT were measured (n = 693), regardless of the quadrant and the irradiated area. An equal number of anterior teeth were tested in group CON. Results: There was no significant difference between the %SpO2 levels in group RT (92.7%; standard deviation, ± 1.83) and group CON (92.6%; standard deviation, ± 1.80). All teeth in RT and CON groups showed a positive response to the thermal test. All tested teeth were considered vital. Conclusions: Pulp %SpO2 was found to be within normal limits 4–6 years after RT. This suggests that RT may not have a long-term influence on pulp vitality, and reported short-term changes in pulpal microcirculation because of RT may be temporary. (J Endod 2016;42:886–889)  

Key Words  
Blood flow, cancer, dental pulp, microcirculation, pulse oximetry, radiotherapy  

IONizing radiation can be used to control cell growth. Radiotherapy (RT) uses ionizing radiation primarily for the treatment of head and neck malignancies. High doses of radiation to large areas such as the oral cavity, teeth, maxilla, mandible, and salivary glands may result in a variety of undesired side effects (4–5). It is common that teeth are in the pathways of radiation during head and neck treatment. Inside a tooth, the dental pulp is a specialized loose connective tissue that is highly innervated and vascularized and entirely surrounded by hard tissues, including dentin and enamel. This particular encapsulation of the pulp tissue allows for distinctive physiological interactions with other tissues (6, 7). Continuous or transient inflammatory changes in the pulp can be caused by bacterial injuries from caries, mechanically by dental trauma, but also biochemically because of ionizing radiation (8–10). RT may potentially lead to decreased vascularization within the dental pulp, resulting in late effects such as fibrosis and atrophy (2, 3, 11). Regarding dental treatment planning, the determination of the pulp status is one of the most important aspects of endodontic diagnosis. Common chairside diagnostic methods such as cold or electric tests only assess the sensitivity of a tooth by evaluating the neuronal response of the pulp organ but fail to address the vitality of the tissue that is dependent on blood supply and oxygenation. One of the means to determine the vitality of the pulp is a pulse oximeter, which allows the assessment of the microcirculation within the dental pulp by measuring the oxyhemoglobin (HgbO2) saturation of the blood (12–14). Several studies already defined parameters for the use of pulse oximeter in determining pulp vitality, proving that there is a correlation between blood oxygenation in the index finger and incisors and canines (9, 15–17). These investigations also demonstrated that pulse oximetry is a safe and reliable method to identify devitalized teeth. Moreover, pulse oximetry may potentially be used to determine different stages of pathologic processes affecting the pulp (18). We have already reported changes in the oxygen saturation rate in teeth of patients undergoing RT in the head and neck area assessed by pulse oximetry (19). However, very few clinical data are available that compare the pulp response with sensitivity tests and other physiometric tests several years after patients had received RT in the head and neck area (8, 20, 21).  

The aim of this study was to evaluate the influence of ionizing radiation on pulp vitality through the measurement of pulpal oxygenation levels (%SpO2) in patients with malignant head and neck tumors at 4–6 years after RT.
Materials and Methods

This investigation was approved by the Ethics Committee of the Sírio-Libanês Hospital (São Paulo, Brazil; protocol #130). An informed consent was obtained from all human subjects who participated in this study. In total, 180 patients who agreed to participate in this investigation were selected for this study. Group RT had 90 participants who had received RT for malignant head and neck tumors at the Hospital Sírio-Libanês 4–6 years ago, including male and female patients between the ages of 35 and 65. Group CON had 90 participants, including male and female patients between the ages of 35 and 65, with no history of malignant head and neck tumors or RT.

Before the investigation, digital periapical radiographs were taken of the teeth to be tested to evaluate the presence or absence of degenerative or resorptive processes in the pulp chamber or within the root canal system, as well as fractures of the alveolar processes, widening of the periodontal ligament, or periapical changes such as bone rarefactions or condensations.

Patient information including sex, age, tumor location, histologic grade of the tumor, TNM cancer staging system, radiation doses (Gy), as well as medical and dental history of each participant were recorded. Pulpal %SpO2 was recorded once per tooth on intact crowns or restorations or condensations. The periodontal ligament, or periapical changes such as bone rarefactions or condensations.

Pulpal %SpO2 was recorded once per tooth on intact crowns or restorations not larger than 2 mm located away from the area to be tested. In both groups, teeth with a history or presence of pain, affected by dental trauma or cavities, changes in color of the clinical crown, with periodontal changes (pockets > 3 mm, mobility > I, or gingival edema), or pain on apical palpation and/or vertical or horizontal percussion were excluded from the study. The pulse oximetry measurements were carried out in the index fingers of the patients by using an Oxygraph pulse oximeter (System Partner, São Paulo, Brazil) with Y-type sensors, adapted for dentistry and previously described (15) (Fig. 1). Oxygen saturation was then measured in the teeth selected of the same patient. Sensors were placed parallel to each other under relative isolation on the vestibular (emitting diode) and lingual (receptor diode) faces of the tooth (Fig. 2). Student’s t test was used for statistical evaluation.

Results

The mean age of the participants in group RT was 49.4 years (male, 50.3 years; female, 48.5 years), and it was 49.6 years in group CON (male, 51.1 years; female, 49.1 years). All patients in group RT had a history of intensity modulated radiation therapy (IMRT), and the mean amount of total radiation delivered to the tumor sites was 61.8 Gy. The most prevalent site of head and neck cancer was the oropharynx (66%), followed by the oral cavity (20%), the nasopharynx (8%), and the hypopharynx (6%).

A total of 693 teeth were tested in group RT, including 344 maxillary incisors (n = 240) and canines (n = 104) and 349 mandibular incisors (n = 240) and canines (n = 109). In group CON, a total of 693 teeth in matching sites were tested, including 350 maxillary incisors (n = 235) or canines (n = 115) and 343 mandibular incisors (n = 225) or canines (n = 118). All 1386 teeth that were tested demonstrated positive responses to cold thermal testing with difluorodichloromethane at −50°C (EndoFrost; Roeko, Langenau, Germany).

The mean of %SpO2 recorded in group RT was 92.7% (standard deviation [SD], ± 1.83%), and it was 92.6% (SD, ± 1.80%) in group CON. There were no statistically significant differences between the groups (Table 1).

Discussion

The use of pulse oximetry as an objective tool to determine pulp vitality has been demonstrated for teeth with a history of dental trauma (16, 20). However, there is still little knowledge about the use of pulse oximetry for the evaluation of teeth in situations other than trauma (13). There are conflicting reports on the effects of RT on the dental pulp. On the basis of bleeding of the pulp during endodontic treatment, one study reported serious damaging effects on pulp vitality (21), whereas several other investigations showed no differences between irradiated and non-irradiated pulp tissue (22, 23).

Our previous report (19) demonstrated that the mean SpO2 evaluated at 4 different points in time during and after RT changed considerably, varying from 93% (before RT) to 83% (at the beginning of RT with radiation doses between 30 Gy and 35 Gy), 77% (at the end of RT with radiation doses between 60 Gy and 70 Gy), and last, 85% (4–5 months after the beginning of the cancer treatment). Although this demonstrated a decrease in the overall blood flow in the pulp short-term after RT (<6 months), the data obtained from this study suggest that this is not a long-term consequence of RT.
This study investigated long-term changes in pulp oxygenation levels after RT therapy in teeth with a clinical diagnosis of a healthy pulp. The investigated teeth were free from large restorations or decay as well as significant periodontal disease. Teeth with extensive restorations are generally inappropriate for pulse oximetry measurements. Also, teeth with large restorations or decay may possibly demonstrate changes in the pulp deriving from inflammation or tertiary dentin formation in the pulp chamber or coronal area of the root, affecting pulse oximetry measurements per se and statements regarding the effects of RT. Moreover, there is no consensus in the endodontic community as to what extent periodontal disease affects the pulp. Thus, it remains speculative as to what extent radiation from head/neck RT may cause different or additional changes in the pulp of teeth with large restorations, decay, or periodontal disease.

Because it was shown that there are changes in the overall structure and vascularization of tumor tissues because of the fractionation of RT, it was suggested that the same process may occur in healthy regular connective tissues, although they may only be affected by lower radiation doses than the actual tumor tissues. Thus, the same sequence of events may be observed: hyperemia, vascular inflammation, ischemia, and possibly tissue hypoxia and necrosis.

The results of this clinical study do support the hypothesis that irradiated pulp affected by doses rendered for RT in the head and neck region may be capable of regaining healthy oxygenation levels and blood flow characteristics. Blood vessels in the dental pulp differ only in relation to their spatial architecture inside the pulp chamber and the root canals from other blood vessels (12), because similar to all the other vessels in the organism, they stain positive for CD34. The latter may be an indication of the ability for remodeling and vasculogenesis by pulpal blood vessels. This was supported by the findings of Nagatsu et al. (24), who demonstrated that tumor blood vessels that stained positive for CD31, CD34, and CD105 were considered to be representative of new vessels with a strong remodeling ability, thus showing the ability for recovery of the blood vessel architecture.

Differences between the young adult and the mature adult pulp only involve a transformation of the cells, without any alteration in Weibel-Palade bodies (25). These findings opened new perspectives and pointed to all the other vessels in the organism, they stain positive for CD34. The latter may be an indication of the ability for remodeling and vasculogenesis by pulpal blood vessels. This was supported by the findings of Nagatsu et al. (24), who demonstrated that tumor blood vessels that stained positive for CD31, CD34, and CD105 were considered to be representative of new vessels with a strong remodeling ability, thus showing the ability for recovery of the blood vessel architecture.

Conclusion

The findings of this study suggest that the dental pulp in the pathway of ionizing radiation during RT of the head and neck region may not undergo either a complete loss or a decrease in vasculature and blood flow 4–6 years after RT. The clinical changes commonly observed in the pulpal microcirculation, which were demonstrated to occur in the short-term, may only be of a temporary nature. This may suggest that often recommended preventive endodontic treatments or tooth extractions in patients who will receive RT could be prevented on a larger scale.

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The authors deny any conflicts of interest related to this study.

References


