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 (%SpO_2) 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 %SpO_2 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 %SpO_2 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 %SpO_2 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 (1–5).

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 pulpal 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 (HgO_2) 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 (%SpO_2) in patients with malignant head and neck tumors at 4–6 years after RT.

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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 $\%SpO_2$ 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.

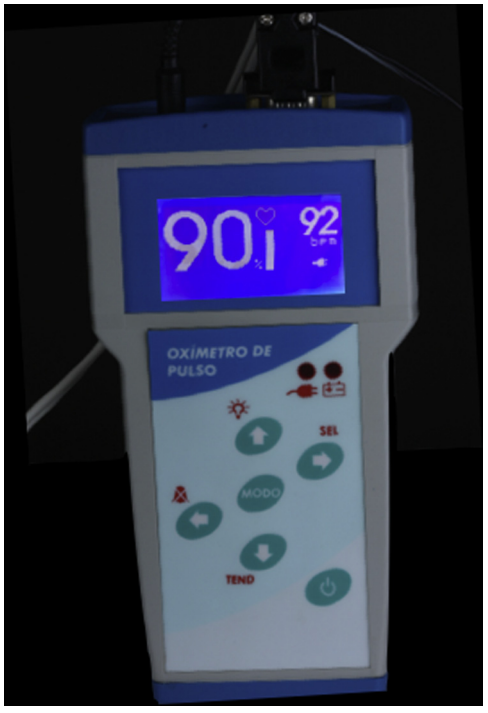

Figure 1. Pulse oximeter, reading of pulpal oxygen saturation.

Figure 2. Pulse oximetry device with positioned sensor.

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 $\%SpO_2$ 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 few reports on the use of pulse oximetry for teeth in the pathways of ionizing radiation and, in particular, on the long-term fate of pulp tissue in irradiated areas.

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 SpO_2 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.