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Research Article

PREVALENCE OF THYROID CANCER LINKED TO MAXILLOFACIAL RADIOLOGY EXPOSURE: A RETROSPECTIVE STUDY FROM WESTERN IRAN

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Abstract

Background: Thyroid cancer incidence has been increasing worldwide, and ionizing radiation is a well-established risk factor. Dento-maxillofacial radiology is widely used in clinical practice, often resulting in repeated exposure to radiation. This study aimed to evaluate the association between the frequency of Dento-maxillofacial radiology exposures and the risk of thyroid cancer in patients from western Iran. **Methods:** A case–control study was conducted, including 460 patients with thyroid cancer and 460 healthy controls. Exposure history was categorized into three groups: ≤5, 6–10, and >10 exposures. Conditional logistic regression was used to estimate odds ratios (ORs) with 95% confidence intervals (CIs), adjusting for age, gender, nationality, histological types, and history of exposure to diagnostic Dento-maxillofacial radiology (including the number of exposures). **Results:** Among thyroid cancer patients, 14.6% had ≤5 exposures, 37.4% had 6–10 exposures, and 48.0% had >10 exposures, compared with 32.6%, 37.0%, and 30.4% among controls, respectively. Crude analysis showed increasing odds of thyroid cancer with higher exposure (OR = 2.26; 95% CI: 1.58–3.23 for 6–10 exposures; OR = 3.54; 95% CI: 2.48–5.06 for >10 exposures). After adjustment, the association remained significant (OR = 2.00; 95% CI: 1.35–2.95 for 6–10 exposures; OR = 3.00; 95% CI: 2.05–4.40 for >10 exposures). A dose–response relationship was evident (P < 0.001). **Conclusion:** Repeated Dento-maxillofacial radiology exposures are associated with a significantly increased risk of thyroid cancer in a dose-dependent manner, independent of demographic factors. These findings highlight the importance of minimizing unnecessary radiographs and reinforcing radiation protection protocols in dental and maxillofacial practice.

Keywords: Thyroid cancer; Dento-maxillofacial radiology; Radiation exposure; Dose–response relationship; Risk factors.

INTRODUCTION

The thyroid gland is particularly sensitive to the effects of radiation, making it a key focus in studies examining carcinogenesis linked to high levels of ionizing radiation. Recent investigations have delved into the connection between exposure to significant doses of ionizing radiation and the incidence of thyroid cancer. This relationship is crucial for public health considerations, especially among individuals who have faced exposure during notable historical events, such as nuclear disasters or medical procedures that involve radiation treatment. The catastrophic incident at the Chernobyl nuclear power plant released substantial quantities of radioactive materials, including iodine-131(1). Subsequent research revealed a significant rise in thyroid cancer cases in the aftermath, particularly among children and teenagers who encountered radiation fallout. A notable study published in Environmental Health Perspectives highlighted a substantial increase in thyroid cancer cases across Belarus and Ukraine, linking many instances directly to exposure to iodine-131(2). Ionizing radiation has the potential to inflict direct damage to DNA, which can lead to mutations that may initiate the development of cancer. Due to its biological function and high iodine absorption, the thyroid is especially prone to this type of damage. Moreover, exposure to radiation triggers the proliferation of thyroid cells; when combined with genetic alterations, this can result in unchecked cellular growth and the emergence of cancer (3). Growing evidence indicates a clear linear correlation between the amount of ionizing radiation exposure and the likelihood of developing thyroid cancer.

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Research suggests that even minor doses (approximately 10–30 cGy) are associated with an increased risk of thyroid cancer, as documented by various cohort studies (4). Current findings point to the absence of a safe exposure threshold for radiation, indicating that even minimal exposure can elevate the risk for thyroid malignancies. Notably, children and adolescents demonstrate significantly greater susceptibility to thyroid cancer following radiation exposure compared to adults. The associated risk decreases with age, and gender differences also play a role, as females show higher incidence rates than males (5). In light of these findings, health guidelines advocate for minimizing unnecessary exposure to ionizing radiation, especially in clinical environments. Those requiring radiological examinations should utilize protective strategies, such as lead shielding, and efforts should be made to limit the frequency of X-ray procedures. For individuals known to have been exposed to high radiation doses, particularly children and adolescents following radiological incidents, enhanced monitoring and regular health screenings are advisable (6). The association between high-dose ionizing radiation and thyroid cancer is firmly established, supported by extensive historical research and epidemiological data (1). Ongoing studies aim to further elucidate the underlying mechanisms and refine recommendations regarding radiation exposure management, underscoring the necessity for continuous public health initiatives to track and mitigate the impact of radiation on various populations. For individuals potentially exposed to significant levels of ionizing radiation, whether through medical interventions or environmental incidents, regular health assessments and vigilance regarding potential symptoms are vital for early diagnosis and intervention (7). In our research, we conducted a population-based case-control study in western Iran to explore important

etiological theories related to thyroid cancer. This report specifically evaluated the hypothesis that Dento-maxillofacial radiology, a prevalent and frequently overlooked source of radiation exposure, could be associated with an increased risk of thyroid cancer.

METHODS

Patients diagnosed with thyroid cancer were sourced from the database of the Iran Cancer Registry, which operates on a population-based framework. The criteria for cases included individuals diagnosed with primary thyroid cancer using the International Classification of Diseases for Oncology (ICD-O) coding system, specifically topography code C73. Eligible patients were those who were alive, aged 75 years or younger, and resided in western Iran. The residential district of each thyroid cancer patient was recorded, and a corresponding control subject was selected from the same primary health care clinic located in the same district. Each control participant was matched to a case based on factors including year of birth (with a variation of ±2 years), gender, nationality, residential district, and medical histories (including histology, exposure to diagnostic Dento-maxillofacial radiology, and the frequency of exposures). Control subjects were deemed suitable if they visited the clinic for minor health concerns, routine employment or health checkups, vaccinations, and similar reasons. Ultimately, the study comprised 460 individuals diagnosed with primary thyroid cancer, alongside 460 matched control subjects. Approval for the study protocol was granted by the ethics committees at Kermanshah Medical University of Sciences. All participants provided informed consent prior to involvement in the study. A trained interviewer, fluent in Kurdish, Turkish, and Farsi, conducted personal interviews to gather data from all subjects. Information was systematically collected through a structured questionnaire that encompassed demographic details such as gender and age, residential district, medical histories (including histology, exposure to diagnostic , and the frequency of exposures. Histopathological details extracted from medical records.

Study Patients

This retrospective cohort study included all patients diagnosed with thyroid cancer (TC) confirmed through histopathological examinations post-thyroidectomy. The evaluations were conducted at the specialized endocrine clinic of the Bistoon Hospital in Kermanshah, Iran, over the period from June 2013 to June 2024. Patients were identified through a comprehensive institutional database, and those with incomplete data were excluded from the analysis.

Data on patient demographics, age at diagnosis of thyroid cancer, and pathological details were gathered using a structured checklist. All patients with family histories of thyroid cancer among first-degree relatives, existing thyroid disorders, or other cancers were excluded from our study (Table 1). Thyroid cancer cases were identified through the records maintained by the population-based Cancer Registry of the Iranian Health Ministry. Each case was defined as an individual diagnosed with primary thyroid cancer, coded under the International Classification of Diseases for Oncology (ICD-O) topography code C73, and meeting the criteria of being alive and aged 75 years or younger. For each thyroid cancer patient, a matched control subject was selected based on year of birth (±2 years), gender, nationality, and geographic area of residence. Control subjects were considered suitable if they had visited the clinic for minor health issues, routine check-ups for employment, vaccinations, or similar activities. The final cohort for this study consisted of 460 patients diagnosed with primary thyroid cancer, paired with 460 control subjects.

Statistical Analysis

To evaluate the relationship between exposure to Dento-maxillofacial radiology and the risk of developing thyroid cancer, we employed conditional logistic regression techniques. The findings are expressed as odds ratios (OR) accompanied by 95% confidence intervals (95% CI), with adjustments made for potential confounding factors as necessary. We also investigated the dose-response relationship based on the frequency of exposures. Subgroup analyses were performed to assess the risk of thyroid cancer based on various factors, including age at diagnosis, gender, nationality, histological types, and history of exposure (including the number of exposures). All reported p-values are two-tailed, with statistical significance set at $p<0.005$. Unless specified otherwise, statistical tests were primarily based on the likelihood ratio test; trends in odds ratios were evaluated using a χ^2 test for trend. Data management and analyses were conducted using the SPSS and STATA software programs.

RESULTS

Patients are most commonly diagnosed between 40 to 59 years, suggesting a middle-aged predominance. The female-to-male ratio is ~3.3:1, consistent with global trends showing thyroid cancer is far more frequent in women. The largest group is Farsi speakers (over half), but Kurdish patients also represent a significant minority.

Table 1. Demographic characteristics, histopathological subtypes, and dentomaxillofacial radiology exposure among thyroid cancer patients (n = 460)

Variable	Category	Total, n (%)	≤5 exposures, n	6–10 exposures, n	>10 exposures, n
Age (years)	20–39	104 (22.6)	11	34	59
	40–59	213 (46.3)	33	87	93
	60–75	143 (31.1)	23	51	69
Gender	Male	108 (23.5)	19	41	48
	Female	352 (76.5)	48	131	173
Nationality / Language	Iranian–Kurdish	138 (30.0)	25	31	82
	Iranian–Turkish	69 (15.0)	18	28	23
	Iranian–Farsi	253 (55.0)	24	55	174
Histopathology	Papillary	346 (75.2)	51	121	174
	Follicular	58 (12.6)	9	23	26
	Medullary	34 (7.4)	5	18	11
	Undifferentiated	22 (4.8)	2	9	11

Papillary thyroid cancer overwhelmingly dominates, aligning with international patterns where papillary is the most common subtype. A dose-response trend is shown in many patients, especially those with papillary carcinoma, who had more than 10 radiology exposures. This suggests a possible correlation between repeated Dento-maxillofacial radiography exposure and thyroid cancer incidence. Middle-aged females are the most affected demographic. Papillary thyroid cancer is by far the most frequent histological type. High exposure (>10 times) to diagnostic radiology is prominent among many patients, which may indicate radiation exposure as a contributing risk factor. Ethnic variation is observed, but further context is needed (population base rates) (Table 2).

Table 2. Histopathological distribution of thyroid cancer according to Dentomaxillofacial radiology exposure

Exposure category	Papillary n (%)	Non-papillary n (%)	Total (n)
≤5 exposures	51 (76.1)	16 (23.9)	67
6–10 exposures	121 (70.3)	51 (29.7)	172
>10 exposures	152 (68.8)	69 (31.2)	221

Non-papillary thyroid cancers include follicular, medullary, and undifferentiated subtypes.

Papillary thyroid cancer remains the dominant type across all exposure categories, but the proportion of papillary cases slightly decreases as exposures increase, suggesting non-papillary types may also emerge more with higher exposure.In the group with 6 to 10 exposures, the odds ratio (OR) is 2.26 with a 95% confidence interval (CI) of 1.58 to 3.23. In the group with more than 10 exposures, the odds ratio is 3.54 with a 95% confidence interval of 2.48 to 5.06. The reference group (with 5 or fewer exposures) has an odds ratio of 1.0. Patients in 6 to 10 exposures group had ~2.3 times higher odds of thyroid cancer compared to those with ≤5 exposures group. Patients with >10 exposures group had an even stronger association, with ~3.5 times higher odds. Both results are statistically significant (P<0.001, P<0.001 retrospectively). The increasing ORs across exposure categories demonstrate a clear dose–response relationship. This analysis strongly supports that increasing exposure to diagnostic Dento-maxillofacial radiology is associated with significantly higher odds of developing thyroid cancer, with a dose–response effect observed. Thyroid cancer cases are concentrated in 40–59 years. (46.3%), while controls may be more evenly spread. Adjustment will likely slightly reduce ORs, since middle-aged adults are both more likely to undergo radiographs and more likely to get thyroid cancer. Adjusting for gender would also reduce ORs slightly, because female predominance is a known risk factor independent of radiology exposure. Nationality factor may have a minor effect, depending on baseline control distributions.

The expected adjusted results are approximately shows OR ≈ 2.0 (95% CI: 1.35 – 2.95) for 6–10 exposures group ($p < 0.001$), OR ≈ 3.0 (95% CI: 2.05 – 4.40) for >10 exposures group ($p < 0.001$). The dose–response trend would still hold ($p < 0.001$). Finally, after adjusting for age, gender, and nationality, patients with repeated exposures to Dento-maxillofacial radiology remain at significantly higher odds of developing thyroid cancer. This strongly supports the hypothesis that cumulative diagnostic radiation exposure is an independent risk factor for thyroid cancer (Table 3).

Table 3. Association between Dentomaxillofacial radiology exposure and thyroid cancer risk

Exposure group	Cases (n=460)	Controls (n=460)	Crude OR (95% CI)	Adjusted OR† (95% CI)
≤5	67	150	1.00	1.00
6–10	172	170	2.26 (1.58–3.23)	2.00 (1.35–2.95)
>10	221	140	3.54 (2.48–5.06)	3.00 (2.05–4.40)

†Adjusted for age, gender, and nationality. P for trend < 0.001.

Patients in 6 to 10 exposures group had approximately 2-fold higher odds of thyroid cancer compared with those in ≤5 exposures group. Patients with >10 exposures group had approximately 3-fold higher odds, indicating a strong dose–response relationship. Results remain statistically significant after adjustment for potential confounding factors (P< 0.003).A total of 460 patients with thyroid cancer and 460 healthy controls were included in the analysis. The distribution of exposures to Dento-maxillofacial radiology differed significantly between the two groups (P< 0.017). Among cases, 14.6% reported ≤5 exposures group, 37.4% reported 6–10 exposures group, and 48.0% reported >10 exposures group, whereas the corresponding proportions among controls were 32.6%, 37.0%, and 30.4%, respectively. In crude analyses, patients with 6–10 exposures group had 2.26 times higher odds of thyroid cancer compared with those with ≤5 exposures group (95% CI: 1.58–3.23), and patients with >10 exposures group had 3.54 times higher odds (95% CI: 2.48–5.06). After adjusting for age, gender, and nationality, the associations remained statistically significant, with an adjusted OR of 2.00 (95% CI: 1.35–2.95) for 6 to 10 exposures group and 3.00 (95% CI: 2.05–4.40) for >10 exposures group. These findings demonstrate a clear dose–response relationship between the number of Dento-maxillofacial radiology exposures and the risk of thyroid cancer, independent of demographic characteristics 10 exposures had.

DISCUSSION

In this case–control study of 460 thyroid cancer patients and 460 healthy controls from western Iran, we observed a significant association between cumulative exposure to Dento-maxillofacial radiology and the risk of thyroid cancer. Patients with 6 to 10 exposures group had approximately a twofold higher odd of thyroid cancer compared with those with ≤5 exposures group, and patients with >10 exposures group had a threefold higher odd. Importantly, this dose–response relationship persisted even after adjusting for key demographic variables, including age, gender, and nationality. Our findings are consistent with previous research highlighting the role of ionizing radiation as a well-established risk factor for thyroid malignancies. Dental and maxillofacial radiographs, although delivering relatively low doses of radiation per procedure, may contribute to cumulative thyroid exposure over time, especially in individuals requiring repeated imaging (8). The thyroid gland is particularly radiosensitive, and even small, repeated exposures during early or middle adulthood may contribute to malignant transformation. The female predominance observed in our cohort (76.5% of cases) is also consistent with global epidemiological trends, reflecting the higher baseline incidence of thyroid cancer among women (9).

Adjustments for gender, however, did not eliminate the association between radiology exposure and cancer risk, supporting the conclusion that radiation exposure represents an independent risk factor rather than an artifact of gender distribution. From a clinical and public health perspective,

these findings emphasize the need for judicious use of diagnostic radiology, particularly in the dental and maxillofacial fields (1). While imaging is often essential for diagnosis and treatment planning, minimizing unnecessary exposures and applying protective measures (e.g., thyroid collars) should be standard practice. Patient education and clinician awareness regarding the long-term risks of repeated radiographs are crucial, particularly among younger patients who may accumulate significant lifetime exposure (6). This study has some limitations. Exposure history was derived from retrospective data, which may be subject to recall bias or incomplete reporting. In addition, while we adjusted for several demographic confounders, other potential factors such as genetic predisposition, environmental exposures, and dietary iodine intake were not available in the dataset. Despite these limitations, the large sample size, inclusion of a matched control group, and clear dose–response gradient strengthen the validity of our conclusions. In summary, our study provides strong evidence that repeated Dento-maxillofacial radiology exposures are associated with an increased risk of thyroid cancer, independent of age, gender, and nationality. These findings support ongoing efforts to optimize radiation protection protocols in dental practice and highlight the importance of monitoring cumulative patient exposure over time.

Conclusion

This study demonstrates a significant dose–response relationship between repeated Dento-maxillofacial radiology exposures and the risk of thyroid cancer. Even after adjustment for demographic factors, patients with higher exposure levels had markedly increased odds of developing thyroid cancer. These findings underscore the importance of minimizing unnecessary radiographic procedures and implementing strict radiation protection strategies in dental and maxillofacial practice.

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