Radiation-Induced Parotid Mucoepidermoid Carcinoma: A Systematic Review

Omar Ramadan, PhD
Independent Researcher, Paterson, NJ 07533, USA

ABSTRACT

Background: Mucoepidermoid Carcinoma (MEC) of the parotid gland has been reported in patients who have been previously exposed to radiation. The purpose of this article is to review the literature examining radiation-induced parotid gland MEC.

Procedure: A PubMed search of related articles in English was performed using a combination of the following keywords: “radiation induced parotid tumors,” “radiation induced salivary gland tumors,” “radiation induced parotid MEC,” “radiation induced salivary gland MEC.”

Results: The search results indicated 18 related articles describing the condition of 40 patients who have been previously exposed to radiation and subsequently developed parotid MEC. According to pre-existing studies, acute lymphoblastic leukemia (ALL) was a common observation among the patients following the initial diagnosis. The patients were divided into two groups on the basis of the treatment they received which included patients subjected to radiotherapy (RT) alone (n=13) and patients subjected to both radiotherapy and chemotherapy (n=27). The recorded latent time for secondary MEC development was significantly reduced in the chemoradiotherapy group of patients relative to the group undergoing radiotherapy alone. The overall survival rate for patients recorded over a period of 2 and 5 years was recorded as 97.4% and 95.4% respectively. The overall locoregional control rates recorded over a period of 2 years and 5 years were 97.4% and 93.1% respectively. There was no significant difference in the recorded survival or locoregional control rates between the groups of patients exposed to radiation alone or a combination of chemotherapy and radiotherapy.

Conclusion: Radiation-induced parotid MEC has an excellent prognosis supporting the survival of over 90% diagnosed patients.

KEY WORDS: Radiation induced parotid tumors; Radiation induced salivary gland tumors; Radiation induced parotid MEC; Radiation induced salivary gland MEC.

ABBREVIATIONS: MEC: Mucoepidermoid Carcinoma; ALL: Acute Lymphoblastic Leukemia; RT: Radiotherapy; LT: Latent time.

INTRODUCTION

Salivary gland tumors are uncommon tumors that represent about 1% of head and neck tumors, only 5% of which occur among children. Among epithelial tumors of the salivary glands, mucoepidermoid carcinoma (MEC) is the most frequently observed histological type of cancer occurring in both adults and children. It is also the most common type of parotid gland malignancies. Parotid gland MEC may be characterized by symptoms such as the formation of a painless mass, facial weakness, referred otalgia, trismus and parenthesis. MEC can occur either as a primary or secondary malignancy. Exposure to radiation has been associated with an increased risk of developing secondary parotid MEC. Multiple cases have been reported about the incidence of secondary MEC in patients exposed to radiotherapy. Long-term evaluation and a high index of suspicion for second cancers are mandatory for all patients had radiotherapy previously. The secondary salivary MEC usually develop years or even decades after treatment of the first neoplasm has been completed. Since the survival of patients with cancer is improving, particularly amongst children, awareness of the spectrum of possible second tumors like parotid gland MEC is of increasing importance. The purpose of our article is to review...
the literature investigating the cases of parotid MEC induced by radiation.\textsuperscript{1,3}

**MATERIALS AND METHODS**

**Search Strategy**

A systematic review was conducted for all cases of radiation induced Parotid MEC from 1967 to 2016 using the PubMed database.

Search criteria were input as “radiation induced parotid tumors”, “radiation induced salivary gland tumors,” “radiation induced parotid MEC,” and “radiation induced salivary gland MEC.”.

Six hundred seventeen initial articles were obtained. Articles were then filtered to exclude non-human and non-English language research.

Abstracts were first reviewed to search for articles that discussed cases of MEC induced by radiation occurring in the parotid gland and full-text articles were subsequently selected and reviewed for extraction of data. References of the included studies were examined for additional cases.

**Selection Criteria and Data Extraction**

All English, human studies that reported individual data for radiation induced parotid mucoepidermoid carcinoma were included if they reported diagnosis, treatment, follow-up, and outcome. Non-human, radiologic, cadaveric, anatomical, and histological studies were excluded, as were sources with insufficient or unextractable data. Articles with unobtainable full text were also excluded.

Outcome measures extracted included: demographic data, radiation dose for primary disease, latent time, primary treatment modality, secondary parotid MEC treatment, follow-up, recurrence, metastasis.

Two-year overall survival and locoregional control were calculated using the Kaplan-Meier method. Differences in the survival rates were assessed by the log-rank test. All \( p \) values were two sided, and a \( p \) value <0.05 was adopted as the threshold for significance (Figure 1).

**RESULTS**

The final PubMed searches using the keywords yielded 18 studies comprising a total of 40 patients which were left for analysis. All 18 studies included individual patient data that was extractable and fit the minimum criteria for inclusion (Table 1).

**Patients Characteristics**

Our study yielded 40 patients with RT related MEC of parotid gland. The median age during primary diagnosis was 11.9 years (range 0.3-28 years); the male to female ratio was 17/23 (Table 2).

**Initial Diagnosis conditions**

The most commonly observed results of diagnosis were ALL (n=14), acne and skin disorders (n=6), and Hodgkins lymphoma (n=5). The other results following diagnosis included thyroid papillary tumor (n=3), AML (n=2), NPC (n=2), rhabdomyosarcoma (n=2) and astrocytoma (n=2). There was one recorded case each of CML, medulloblastoma, neuroblastoma, retinoblastoma, recurrent sore throat.

The treatment for initial tumor or similar condition in-
<table>
<thead>
<tr>
<th>Age at RT Exposure</th>
<th>Age At diagnosis</th>
<th>LT</th>
<th>Primary condition</th>
<th>Treatment for Initial condition</th>
<th>Treatment for Secondary MEC</th>
<th>Outcomes</th>
<th>Follow Up</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 12 28 16</td>
<td>M 17 32 15</td>
<td>F 28 34 8</td>
<td>Hodgkin</td>
<td>RT+C 44 Gy</td>
<td>Surgery</td>
<td>NED</td>
<td>86 mo</td>
<td>I</td>
</tr>
<tr>
<td>M 15 58 43</td>
<td>F 15 79 64</td>
<td>M 15 21 6</td>
<td>Acne</td>
<td>RT Low dose</td>
<td>Surgery</td>
<td>NED</td>
<td>6 mo 1 yr</td>
<td>I</td>
</tr>
<tr>
<td>M 5 50 45</td>
<td>F 15 10 9</td>
<td>F 3 12 9</td>
<td>ALL</td>
<td>RT+C 18 Gy</td>
<td>Surgery</td>
<td>NED</td>
<td>24 mo 2 yr</td>
<td>I</td>
</tr>
<tr>
<td>F 3 12 9</td>
<td></td>
<td>Prasannan et al</td>
<td>NPC</td>
<td>RT+C 41</td>
<td>Surgery</td>
<td>NED</td>
<td>3 yr alive with distant</td>
<td>III</td>
</tr>
<tr>
<td>5 M 29 6</td>
<td>11 Rhabdomyosarcoma</td>
<td>Whatley et al</td>
<td>NPC</td>
<td>RT+C 37</td>
<td>Surgery</td>
<td>ND</td>
<td>6 yr</td>
<td>III</td>
</tr>
<tr>
<td>3 F 13 8</td>
<td>13 Astrocytoma</td>
<td>M 3 10 3</td>
<td>ALL</td>
<td>RT+C 24</td>
<td>Surgery</td>
<td>NED</td>
<td>6 yr</td>
<td>II</td>
</tr>
<tr>
<td>5 5 9 5</td>
<td>5 CML</td>
<td>F 5 15,5 19 3,5</td>
<td>Thyroid papillary tumor</td>
<td>RT+C 18 Gy</td>
<td>Surgery</td>
<td>ND</td>
<td>3 yr</td>
<td>II</td>
</tr>
<tr>
<td>F 20 39 19</td>
<td>F 3 8 5</td>
<td>Tugcu et al</td>
<td>Thyroid papillary tumor</td>
<td>RT+C 12 Gy</td>
<td>Surgery</td>
<td>NED</td>
<td>4 yr N/V</td>
<td></td>
</tr>
<tr>
<td>M 5 9 4</td>
<td>M 5 10 13</td>
<td>Pierre Olivier Vedrine et al</td>
<td>Astrocytoma</td>
<td>RT+C 50 Gy</td>
<td>Surgery</td>
<td>NED</td>
<td>16 yr</td>
<td>I</td>
</tr>
<tr>
<td>M 5 18 10</td>
<td>F 11,5 17 6,5</td>
<td>Pierre Olivier Vedrine et al</td>
<td>ALL</td>
<td>RT+C 12 Gy</td>
<td>Surgery</td>
<td>NED</td>
<td>2</td>
<td>I</td>
</tr>
<tr>
<td>Name</td>
<td>Gender</td>
<td>Age</td>
<td>Site</td>
<td>Treatment</td>
<td>Outcome</td>
<td>Follow-up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>--------</td>
<td>-----</td>
<td>------------</td>
<td>-----------</td>
<td>---------</td>
<td>-----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Myer et al</td>
<td>M</td>
<td>2</td>
<td>Retinoblastoma</td>
<td>RT+C 54 Gy</td>
<td>None</td>
<td>Dead</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Loy et al</td>
<td>F</td>
<td>9</td>
<td>ALL</td>
<td>RT+C 18 Gy</td>
<td>Surgery</td>
<td>NED</td>
<td>2 I</td>
<td></td>
</tr>
<tr>
<td>Sevelli et al</td>
<td>F</td>
<td>2</td>
<td>ALL</td>
<td>RT+C 12 Gy</td>
<td>Surgery</td>
<td>NED</td>
<td>7 yr I</td>
<td></td>
</tr>
<tr>
<td>Arnold et al</td>
<td>M</td>
<td>20.3</td>
<td>Medulloblastoma</td>
<td>RT+C 50 Gy</td>
<td>Surgery</td>
<td>NED</td>
<td>13 yr I</td>
<td></td>
</tr>
<tr>
<td>Zidar et al</td>
<td>F</td>
<td>1</td>
<td>ALL</td>
<td>RT+C N/V</td>
<td>Surgery</td>
<td>NED</td>
<td>3 I</td>
<td></td>
</tr>
<tr>
<td>Piccinelli et al</td>
<td>M</td>
<td>15</td>
<td>ALL</td>
<td>RT+C 12 Gy</td>
<td>RT</td>
<td>NED</td>
<td>3 yr N/V</td>
<td></td>
</tr>
<tr>
<td>Althan et al</td>
<td>F</td>
<td>6</td>
<td>ALL</td>
<td>RT+C 18 Gy</td>
<td>Surgery ND RT Chemotherapy</td>
<td>NED</td>
<td>2 yr III</td>
<td></td>
</tr>
<tr>
<td>Brito et al</td>
<td>F</td>
<td>48</td>
<td>Thyroid papillary tumor</td>
<td>RT 150 mic</td>
<td>Surgery</td>
<td>NED</td>
<td>3 yr I</td>
<td></td>
</tr>
<tr>
<td>Welstad et al</td>
<td>F</td>
<td>35</td>
<td>Recurrent sore throat</td>
<td>RT Low dose</td>
<td>Surgery</td>
<td>NED</td>
<td>2 I</td>
<td></td>
</tr>
<tr>
<td>Rice et al</td>
<td>F</td>
<td>16</td>
<td>Acne</td>
<td>RT 6 Gy</td>
<td>Surgery</td>
<td>NED</td>
<td>2 yr N/V</td>
<td></td>
</tr>
<tr>
<td>Smith et al</td>
<td>F</td>
<td>10</td>
<td>Scar</td>
<td>RT Low dose</td>
<td>Surgery</td>
<td>NED</td>
<td>10 mo 1 yr N/V</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1:** 18 studies included individual patient data that was extractable and fit the minimum criteria for inclusion.

<table>
<thead>
<tr>
<th>Gender</th>
<th>RT=13</th>
<th>Chemo/RT=27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Female</td>
<td>10</td>
<td>13</td>
</tr>
</tbody>
</table>

**Table 2:** Patients characteristics.
cluded radiotherapy for 13 patients and a combination of chemo-
therapy radiotherapy in 27 patients. The median RT dose deliv-
ered was 28.25 Gy (ranged 6-70 Gy).

**Latent time (LT) from Initial Treatment to Development of**

**Mucceoepidermoid Carcinoma**

The median LT recorded from completion of initial treatment to
diagnosis of MEC was 11.9 years. LT in RT alone and combina-
tion of chemotherapy and RT were 23.7 years and 9.45 years re-
spectively. LT in Chemotherapy-RT group was significantly
lesser than LT in patients who were in the Radiotherapy group
(p<0.01). LT was 38.7 years (21-64 years) in patients treated for
benign conditions relative to 9.7 years (range 3-21 years) in pa-
tients treated for malignant conditions (significant at p<0.01).
There was no statistically significant difference in LT due to the
influence of gender and grade of secondary MEC.

**Secondary MEC Carcinoma Properties**

Tumor grade was reported in 36 cases. 25 cases (66%) were
that of low grade MEC, 6 cases (15%) were that of intermediate
MEC, and 3 cases (7.5%) were that of high grade MEC. There
was no difference in the grade of secondary MEC with respect
to the use of radiotherapy alone or both chemotherapy and radio-
therapy (p=0.05).

The secondary MEC was inside or at the edge of the RT
field in all the patients who were treated initially with RT alone.
For patients who were treated with both RT and chemotherapy,
all except one case of secondary MEC developed inside or at the
edge of RT field.

**Treatment and Outcomes**

A majority of patients were treated with surgery alone (n=27)
67% or in combination with radiation (n=10) 25%. The remain-
ing patients received surgery, combination of chemotherapy and
RT (n=1), and RT alone (n=1).

The median follow-up after diagnosis of secondary
MEC was 4.16 years. The overall survival rates over a period of
2 years and 5 years were recorded as 97.4% and 93.1% respecti-
vely. One patient was dead of medulloblastoma. There was no
statistically significant difference in survival rates with respect
to the treatment for the initially diagnosed condition by chemo-
radiotherapy or by radiotherapy alone.

The overall locoregional control rates recorded over a
period of 2 years and 5 years were 97.4% and 93.1% respective-
ly. Local recurrence was seen in 2 patients treated with surgery
alone. One patient had intermediate MEC, and the other one had
a low grade MEC. There were no regional failures. There was
no statistically significant difference in locoregional control with
respect to the treatment of initially diagnosed condition i.e., by
chemoradiotherapy or by radiotherapy alone.

There was one recorded case of a patient with high
grade MEC who developed distant metastasis. One patient with
low grade MEC had positive regional lymph node at presenta-
tion and was treated with surgery alone. There were no recorded
cases of regional failures.

**DISCUSSION**

The carcinogenic properties of radiation were reported in the
early 20th century. Radiation can damage DNA and lead to clini-
cal conditions due to cross-linking between nucleotide bases,
and single-stranded and double-stranded breaks in the DNA.
The double-stranded DNA breaks and their inappropriate repair
may result in mutations. Radiation may also induce mutations of
tumor suppressor genes, genomic instability and transmissible
instability that maximize the initiation of carcinogenesis. Irradia-
tion may induce development of multiple tumors such as leu-
emia, carcinoma of mucous membranes, sarcomas, and head and
neck carcinoma.

The relationship between irradiation and the head and
neck carcinoma has been extensively studied. Saenger report-
ed 11 cases of development of thyroid tumors, 1 case of car-
icoma of the parotid and submandibular glands respectively
among 1,644 patients who were treated with radiation.20 Epide-
miological studies also, have established a linked between radia-
tion therapy and the development of salivary gland neoplasms.
This relationship has been observed particularly among atomic
bomb survivors and patients who underwent radiation therapy
for treating benign or neoplastic conditions. There are numerous
instances in the literature indicating second malignancies among
patients who underwent treatment for childhood neoplasia.
However, the number of reported cases for salivary gland tumors
was low.4 Garwicz et al reviewed the study of 30,000 children
undergoing treatment for cancer and identified 247 cases of sec-
ondary malignancy, however, only 2 cases of these secondary tu-
mors originated in salivary glands.21 Though most studies report
salivary gland tumors to be benign, radiation-induced salivary
gland tumors are more often associated with malignancies.4

Irradiation may induce the formation of benign and
malignant tumors of the salivary gland. Benign tumors more
commonly occur in the form of pleomorphic adenoma or benign
mixed tumor. Malignant tumors are generally identified with
MEC, myoepithelial, malignant mixed tumor, adenocarcinoma,
adenoacitic carcinoma and acinic cell carcinoma. Modan et al22
reported that the latent time until the development of salivary
gland tumor was 11 years in case of malignancies and 21.5 years
for the benign condition. The data collected following the study
of atomic bomb survivors revealed that the incidence of parotid
MEC increased with radiation dose and that MEC was the most
common histopathological type observed in salivary gland tu-
mor MEC induced by radiation. A similar observation has also
been reported in both the series by Modan et al22 and Beal et al1

Verma et al3 reported 58 cases of salivary gland MEC
induced by radiation and chemotherapy, most of which were low grade MECS and localized in the parotid gland. He observed that the latency time was shorter in case of the patients treated with chemotherapy +/- radiotherapy versus radiotherapy alone. The overall survival rates recorded over a period of 2 years and 5 years were 98% and 93.4% respectively and the locoregional control rates recorded for over 2 years and 5 years were 97.7% and 92.4% respectively.3

All the patients underwent surgical excision of the primary lesion as indicated by the size and location of the tumor. Neck dissection was performed in selected patients with intermediate and high grade pathology, and post-operative radiation was given to any patient with high grade malignancy, positive margins, or local recurrence. When treated aggressively, the prognosis of these patients appears relatively favorable.4 The majority of cases reported for parotid MEC were low grade mucoepidermoid carcinoma, with an excellent prognosis following the complete removal of the tumor.3

This meta-analysis is limited by small number of cases and the incomplete data found in the studies included that may prevent reaching statistically significant results. Although data heterogeneity might better reflect overall global population trends and enable generalization of the findings, many of the included studies have relatively small populations, which subject the analysis to publication bias. This may result in an over- or underestimation of treatment effect.

CONCLUSION

Radiation induced parotid MEC was most commonly diagnosed among females. In most of the reported cases, the initial diagnosis indicated the occurrence of ALL, acne and Hodgkins lymphoma. The latent time for secondary MEC development was significantly shorter in chemotherapy and radiotherapy groups. A majority of patients were treated with surgery alone (n=27) (67%) or in combination with radiation therapy (n=10) (25%). The overall survival rates recorded over a period of 2 years and 5 years were 97.5% respectively and the locoregional control rates recorded over a period of 2 years and 5 years were 97.4% and 93.1% respectively. There was no statistically significant difference in the survival or locoregional control rates between the groups exposed to radiation or a combination of chemotherapy and radiation. There was one recorded case of a patient with high grade MEC who developed distant metastasis. Also, the study indicated one patient with low grade MEC with positive regional lymph node at presentation who was treated with surgery alone. Only 1 case of patient death has been reported on account of medulloblastoma. There has been no evidence of regional failures.

REFERENCES


