Implant survival rate after oral cancer therapy: A review

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S U M M A R Y

The overall impression regarding the success of dental implants (DI) in patients having undergone oral cancer therapy remains unclear. The aim of the present review study was to assess the implant survival rate after oral cancer therapy. Databases were explored from 1986 up to and including September 2010 using the following keywords in various combinations: “cancer”, “chemotherapy”, “dental implant”, “oral”, “osseointegration”, “radiotherapy”, “surgery” and “treatment”. The eligibility criteria were: (1) original research articles; (2) clinical studies; (3) reference list of pertinent original and review studies; (4) intervention: patients having undergone radio- and chemotherapy following oral cancer surgery; and (5) articles published only in English. Twenty-one clinical studies were included. Results from 16 studies reported that DI can osseointegrate and remain functionally stable in patients having undergone radiotherapy following oral cancer surgery; whereas three studies showed irradiation to have negative effects on the survival of DI. Two studies reported that DI can osseointegrate and remain functionally stable in patients having undergone chemotherapy. It is concluded that DI can osseointegrate and remain functionally stable in patients having undergone oral cancer treatment.

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Introduction

Several studies1–5 have reported high osseointegration rates of dental implants (DI) in patients undergoing therapy for systemic disorders (such as diabetes mellitus, Pagets’ disease and breast cancer); however, the overall impression regarding the success of DI in patients having undergone oral cancer therapy remains unclear.

Surgical excision of oral malignancies is often followed by either radiotherapy or chemotherapy or both. According to Granstrom et al.6 irradiated sites are more susceptible to tissue necrosis and consequent loss of implants compared to non-irradiated sites. A reduced salivary flow rate irradiated patients may cause complications such as dental caries (in patients with remaining natural teeth), periodontal disease and oral fungal infections.7–10 Cao and Weischer6 investigated the prognosis of 131 DI in 27 patients having undergone radiotherapy for the management of oral carcinoma. After approximately 2 years of follow-up, the results showed a significantly lower implant survival rate (ISR) in irradiated compared to non-irradiated patients.5 In another study,11 one patient lost three of the nine DI inserted following protracted chemotherapy. In the Schoen study,12 prognosis of implant-retained prosthesis was shown to be superior in non-irradiated patients compared to patients having undergone radiotherapy following oral cancer surgery. Thus, the appropriateness of using DI in irradiated patients may be questioned. On the contrary, some studies13–17 have reported that DI installed in patients having undergone oral cancer therapy, can osseointegrate and remain functionally stable over long durations. In a study by Cuesta-Gil et al.14 the 9-year follow-up results showed a high ISR (92.9%) of DI in irradiated patients. Similar results were reported by Taira et al.17

Since controversy persists over the osseointegration and functional stability of DI in patients having undergone oral cancer treatment; the aim of the present study was to assess the ISR after oral cancer therapy.

Materials and methods

Focused question

The addressed focused question was: “Can DI osseointegrate and remain functionally stable in patients having undergone oral cancer treatment?”

Eligibility criteria

The eligibility criteria were: (1) original research articles; (2) clinical studies; (3) reference list of pertinent original and review
studies; (4) intervention: patients having undergone radio- and chemotherapy following oral cancer surgery; and (5) articles published only in English.

Historic reviews, letters to the editor and unpublished articles were excluded.

Search strategy

The authors searched the MEDLINE/PubMed databases of the National Library of Medicine, Bethesda, Maryland, for appropriate articles addressing the focused question. Titles and abstracts of articles that satisfied the eligibility criteria were screened by the authors and checked for agreement. Databases were explored from 1986 up to and including September 2010 using the following keywords in various combinations: “cancer”, “chemotherapy”, “dental implant”, “oral”, “osseointegration”, “radiotherapy”, “surgery” and “treatment”.

Hand-searching was also performed. The initial search yielded 31 studies. Ten studies, which did not satisfy the eligibility criteria, were excluded (see Further readings). In total, 21 studies12–31 were included and processed for data extraction (Table 1).

Results

Characteristics of included studies

All studies9,12–31 were performed in humans and were either carried out at universities or healthcare centers. The numbers of participants ranged between one subject to 130 individuals. The participants were aged between 13 and 81 years. In 19 studies,9,12–29 the patients had undergone radiotherapy prior to implant installation whereas in two studies30,31 the patients had undergone chemotherapy before DI treatment. The radiation dosages ranged between 20 and 116 gray (Gy). The intermission between the cessation of radio- or chemotherapy (following surgery) and the installation of DI ranged between at least 2 months and 14 years. The number of DI installed in the study participants ranged from 2 to 446. The follow-up duration ranged between 6 months and 10 years following the installation of DI.

Sixteen studies12–17,19,21–29 reported that DI can osseointegrate and remain functionally stable in patients having undergone radiotherapy. The osseointegration success rates reported by these studies12–17,19,21–29 ranged between 68% and 100%,9,12–15,17–27. Three studies9,18,20 cautioned that irradiation has negative effects on the survival of DI in patients having undergone chemotherapy before DI treatment. The radiation dosages ranged between 20 and 116 gray (Gy). The intermission between the cessation of radio- or chemotherapy (following surgery) and the installation of DI ranged between at least 2 months and 14 years. The number of DI installed in the study participants ranged from 2 to 446. The follow-up duration ranged between 6 months and 10 years following the installation of DI.

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In 20 studies9,12–17,19,21–29 implants were inserted in the mandible; however, in one study18 DI were inserted in the maxilla (n = 108) and mandible (n = 338). Adjunct hyperbaric oxygen (HBO) therapy preceding DI installation was performed in four studies15,17,22,23.

Discussion

Over the past years, the use of DI in oral cancer patients having undergone surgery and adjunct cancer therapy (radiotherapy and/or chemotherapy) has increased.14–24 It may be hypothesized that jaw location may also contribute to the success and failure of implant treatment. From the literature reviewed, it seems that the survival and functionally stability of DI is higher in the mandible as compared to the maxilla; however, it should be noted that in all the included studies,9,12–31 DI were inserted exclusively in the mandible; with the exception of the studies by Visch et al.18 and Niimi et al.23 where DI were installed in the mandible and maxilla. Results by Visch et al.18 showed the ISR to be slightly higher in the posterior- as compared to the anterior maxilla; however the difference was not statistically significant. In the Niimi study,23 the number of DI inserted in the maxilla were too low to depict any definite conclusions; yet, it may be speculated that poor bone quality of the maxilla (which was not assessed in this study)23 could be associated with the poor ISR. Due to a scarcity of indexed literature on this regard, we found it exigent to discuss the role of jaw location on the survival of DI in patients having undergone oral cancer therapy.

Osteoradionecrosis is usually observed several years following radiotherapy and is associated with local trauma within the hypovascular–hypocellular hypoxic tissues (which occurs as a result of radiation-induced endarteritis).32,33 Thus, the interval between the end of oral cancer therapy and installation of DI may contribute to the success or failure of osseointegration. Various studies9,12,15–22 have investigated the required time interval between radiotherapy and implant installation that may influence osseointegration; however, the results remain debatable. Marx and Johnson32 reported that the risk of oral complications (particularly osteoradionecrosis) and the probability of implant failure is higher in cases where DI are inserted between one and 6 months following radiotherapy. Similar results were reported by another study9 where DI, installed 6 months following irradiation demonstrated significantly lower ISR. However, the Visch study18 reported no significant differences in the survival of DI inserted less than 12 months (76%) or at least one year (81%) after radiotherapy. In the Werkmeister study30 osseointegration was reported to be negatively influenced in DI installed 2 years following end of radiation therapy; however, the ISR in non-irradiated bone was also reported to be low (approximately 68%).20 It is known alcohol consumption, smoking, poor oral hygiene and systemic conditions (such as poorly-controlled diabetes) are significant risk-factors of periodontal inflammation.2,5,10 It may therefore be argued that such factors may contribute in altering the ISR in patients having undergone oral cancer therapy. Although smokers were excluded in the Werkmeister study,29 however, it remained unclear whether or not the study population was screened for other risk-factors as mentioned above. This may be an explanation for the lower osseointegration rate among non-irradiated patients in this study.30

It is intricate to reach a definitive conclusion regarding the influence of interval on the survival of DI in patients having undergone chemotherapy. Likewise, we did not observe any consistency in influence of interval on the survival of DI in patients having undergone chemotherapy before DI treatment. The radiation dosages ranged between 20 and 116 gray (Gy). The intermission between the cessation of radio- or chemotherapy (following surgery) and the installation of DI ranged between at least 2 months and 14 years. The number of DI installed in the study participants ranged from 2 to 446. The follow-up duration ranged between 6 months and 10 years following the installation of DI.
Table 1

<table>
<thead>
<tr>
<th>Author/s et al.</th>
<th>Year</th>
<th>Aim</th>
<th>Subject/s (mean age/range in years)</th>
<th>Mean radiation dosage in Gy (range)</th>
<th>Interval (in months)</th>
<th>Dental implants inserted (n)</th>
<th>Follow-up (in years)</th>
<th>Osseointegration success rate (%)</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korfage et al.</td>
<td>13–18</td>
<td>To assess the outcome of DIe therapy in irradiated oral cancer patients</td>
<td>50 (61.5–41–81)</td>
<td>40 (12–70)</td>
<td>–</td>
<td>195</td>
<td>5</td>
<td>89.4%</td>
<td>Dental implants can osseointegrate and remain functionally stable in oral cancer patients having undergone surgery and radiotherapy</td>
</tr>
<tr>
<td>Cuesta-Gil et al.</td>
<td>22–16</td>
<td>To assess the outcome of DIe therapy in oncologic patients</td>
<td>111 (52–13–79)</td>
<td>NA (50–60)</td>
<td>At least 12 months (in 34 cases)</td>
<td>706</td>
<td>9</td>
<td>92.9%</td>
<td>Dental implants can osseointegrate and remain functionally stable in patients having undergone surgery and radiotherapy for oncologic disorders</td>
</tr>
<tr>
<td>Schoen et al.</td>
<td>20–13</td>
<td>To assess the outcome of DIe therapy in irradiated and non-irradiated oral cancer patients</td>
<td>50 (61.5–41–81)</td>
<td>60.1 (30–70)</td>
<td>NA</td>
<td>4 implants per patient</td>
<td>At least 18 months</td>
<td>97%</td>
<td>DIe retained prosthesis can osseointegrate and remain functionally stable in patients having undergone therapy for OSCC. This effect is more enhanced in non-irradiated compared to irradiated patients</td>
</tr>
<tr>
<td>Schoen et al.</td>
<td>15–12</td>
<td>To assess the effect of DIe therapy on the osseointegration of dental implants</td>
<td>26 (60.1–47–77)</td>
<td>61.4 (46–116)</td>
<td>At least 1 year</td>
<td>103</td>
<td>3</td>
<td>93.9%</td>
<td>Dental implants can osseointegrate and remain functionally stable in patients having undergone radiotherapy for the treatment of OSCC.</td>
</tr>
<tr>
<td>Schepers et al.</td>
<td>16–14</td>
<td>To investigate the prognosis of DIe supported prostheses in irradiated oral cancer patients</td>
<td>48 (64.8–54–75)</td>
<td>NA (60–68)</td>
<td>9 months</td>
<td>139</td>
<td>9</td>
<td>97%</td>
<td>The implants remained esthetically and functionally successful for up to at least 10 years</td>
</tr>
<tr>
<td>Taira et al.</td>
<td>17–72</td>
<td>To evaluate the outcome of an implant-supported after radiotherapy and hemiglossectomy in a patient with carcinoma of tongue</td>
<td>1 (52-year-old male)</td>
<td>40</td>
<td>13 years</td>
<td>4</td>
<td>10 years</td>
<td>NA</td>
<td>Immplant survival is significantly influenced by location, extent of surgery and by the irradiation dose at the implant site</td>
</tr>
<tr>
<td>Cao and Weischer</td>
<td>9–1</td>
<td>To investigate the prognosis of DIe supported prostheses in irradiated and non-irradiated patients</td>
<td>27 (NA–45–79)</td>
<td>NA (36–76)</td>
<td>6 months</td>
<td>131</td>
<td>At least 2 years</td>
<td>88%</td>
<td>Dermal supported prostheses have significantly lower survival rates in irradiated patients compared to non-irradiated patients</td>
</tr>
<tr>
<td>Visch et al.</td>
<td>18–10</td>
<td>To assess the success of dental implant therapy in patients having undergone oral cancer surgery and radiotherapy</td>
<td>130 (62–34–87)</td>
<td>NA (0 to &gt;than 72)</td>
<td>At least 6 months</td>
<td>446</td>
<td>14 years</td>
<td>78%</td>
<td>Implant survival is significantly influenced by location, extent of surgery and by the irradiation dose at the implant site</td>
</tr>
<tr>
<td>Weischer and Mohr</td>
<td>19–10</td>
<td>To assess the 10-year experience in oral implant rehabilitation of irradiated and non-irradiated cancer patients</td>
<td>40 (55–43–75)</td>
<td>50 (36–72)</td>
<td>13 months</td>
<td>175</td>
<td>10 years</td>
<td>91%</td>
<td>Irradiated patients should be restored with exclusively implant-supported prostheses, without any mucosal contact</td>
</tr>
<tr>
<td>Werkmeister et al.</td>
<td>20–10</td>
<td>To evaluate the risks and complications of rehabilitation with dental implants after tumor surgery and radiotherapy</td>
<td>29 (55–35–79)</td>
<td>54 (42–64)</td>
<td>At least 24 months</td>
<td>109</td>
<td>3 years</td>
<td>68.8% (in non-irradiated bone)</td>
<td>Osseointegration is disturbed after implant placement in oral cancer patients. Irradiation adversely affects soft tissue healing</td>
</tr>
<tr>
<td>Oechslin et al.</td>
<td>21–10</td>
<td>To assess the prognosis of a DIe supported prostheses in a patient having undergone oral cancer therapy</td>
<td>162-year-old male</td>
<td>72</td>
<td>15 months</td>
<td>2</td>
<td>6 months</td>
<td>100%</td>
<td>Dental implants can osseointegrate and the supported prostheses can remain functionally stable in patients having undergone oral cancer therapy</td>
</tr>
<tr>
<td>August et al.</td>
<td>22–10</td>
<td>To assess the prognosis of a DIe supported prostheses in a patient having undergone oral cancer therapy</td>
<td>18(64–46–81)</td>
<td>65.4 (54–75)</td>
<td>44.5 months</td>
<td>18</td>
<td>16.4 months</td>
<td>100%</td>
<td>Dental implants can osseointegrate and the supported prostheses can remain functionally stable in patients having undergone oral cancer therapy</td>
</tr>
</tbody>
</table>
Radiation dosage has been reported to influence osseointegration\(^6\); however, there seems no consensus regarding the radiation dosages to which oral cancer patients should be exposed in order to achieve high ISR. Studies\(^{34,35}\) have reported that radiation dosages exceeding 40–50 Gy may impair bone healing that may in turn jeopardize implant osseointegration. From the literature reviewed, we observed that DI showed up to 100% osseointegration when exposed to radiation dosages up to 65 Gy (Fig. 1). It may be presumed that radiation dosages between 50 and 65 Gy do not negatively influence osseointegration; however irradiated patients should always be consented for the complications that may arise following implant surgery.

Some studies\(^{37,36,37}\) have recommended that HBO therapy should precede implant surgery particularly following radiation doses of more than 50 Gy. HBO therapy has been reported to provoke capillary angiogenesis and bone formation by causing an increased oxygen tension in the irradiated ischemic bone\(^27\); however, the role of adjunct HBO therapy prior to implant treatment remains debatable. In the study by Cao and Weischer\(^9\) adjunct HBO therapy was not performed and the results showed a poorer ISR.

### Table 1 (continued)

<table>
<thead>
<tr>
<th>Author/s</th>
<th>Aim</th>
<th>Subject/s (mean age/range in years)</th>
<th>Mean radiation dosage in Gy(^a) (range)</th>
<th>Interval(^b)</th>
<th>Dental implants inserted (n)</th>
<th>Follow-up</th>
<th>Osseointegration success rate</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niimi et al.(^23)</td>
<td>To assess the prognosis of DI(^e) placed in irradiated tissues from the data of centers in Japan and the United States</td>
<td>22 patients from each center (NA(^c)/NA(^c))</td>
<td>NA(^d) (&lt;25–66) NA(^d)</td>
<td>Approx. 2 years</td>
<td>228</td>
<td>Up to 2 years</td>
<td>88.9% (Japan center) 86% (United States center)</td>
<td>Dental implants can osseointegrate and remain functionally stable in patients having undergone therapy for oral malignancy</td>
</tr>
<tr>
<td>McGhee et al.(^24)</td>
<td>To establish the validity of using osseointegrated implants for dental restoration in patients with head and neck cancer</td>
<td>6 (NA(^c)/NA(^c))</td>
<td>At least 50 (NA(^c))</td>
<td>At least 2 months</td>
<td>26</td>
<td>12 months</td>
<td>92%</td>
<td>Dental implants can osseointegrate and remain functionally stable in patients having undergone oral cancer therapy</td>
</tr>
<tr>
<td>Marker et al.(^25)</td>
<td>To investigate whether or not dental implants can osseointegrate in patients having undergone oral cancer therapy</td>
<td>12 (71/42–81)</td>
<td>50 (40–66)</td>
<td>Approx. 2 years</td>
<td>38</td>
<td>Up to 3.5 years</td>
<td>100%</td>
<td>Dental implants can osseointegrate and remain functionally stable in patients having undergone oral cancer therapy</td>
</tr>
<tr>
<td>Keller et al.(^26)</td>
<td>To investigate the prognosis of dental implant treatment in patients having undergone oral cancer surgery and radiotherapy</td>
<td>19 (57/24–84)</td>
<td>60 (50–66)</td>
<td>Approx. 4 years</td>
<td>98</td>
<td>10 years</td>
<td>99%</td>
<td>Dental implants can osseointegrate and the supported prosthesis can remain functionally stable in patients having undergone radiotherapy</td>
</tr>
<tr>
<td>Taylor and Worthington(^27)</td>
<td>To assess the prognosis of DI(^e) supported prosthesis in patients having undergone oral cancer therapy</td>
<td>61-year-old male</td>
<td>60</td>
<td>7 years</td>
<td>6</td>
<td>7 years</td>
<td>100%</td>
<td>Dental implants can osseointegrate and can remain functionally stable in patients having undergone radiotherapy</td>
</tr>
<tr>
<td>Misch et al.(^28)</td>
<td>To assess the prognosis of DI(^e) supported prosthesis in a patient having undergone oral cancer therapy</td>
<td>56-year-old male</td>
<td>60</td>
<td>NA(^c)</td>
<td>7</td>
<td>NA(^c)</td>
<td>100%</td>
<td>Dental implants can osseointegrate and remain functionally stable in patients having undergone radiotherapy</td>
</tr>
<tr>
<td>Kovács(^30)</td>
<td>To investigate the effect of chemotherapy on the survival and success of dental implants in oral cancer patients</td>
<td>30 (55/NA(^c))</td>
<td>–</td>
<td>10.5 months</td>
<td>106</td>
<td>10 years</td>
<td>99.1%</td>
<td>Chemotherapy did not have detrimental effects on the survival and success of dental implants in oral cancer patients</td>
</tr>
<tr>
<td>Kovács(^31)</td>
<td>To investigate the fate of osseointegrated implants in patients following oral cancer surgery and chemotherapy</td>
<td>45 (53.5 in males/range: NA(^c)) 49.1 in females/range: NA(^c))</td>
<td>–</td>
<td>At least 6 months</td>
<td>162</td>
<td>6 years</td>
<td>97.6%</td>
<td>Dental implants can osseointegrate and remain functionally stable in patients having undergone surgery and chemotherapy</td>
</tr>
</tbody>
</table>

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\(a\) Gray (Unit: joules/kilogram).

\(b\) Interval between conclusion of radiotherapy and dental implant installation.

\(c\) Not available.

\(d\) Oral squamous cell carcinoma.

\(e\) DI: dental implant.
in irradiated compared to non-irradiated patients. Should this poorer ISR be attributed to the absence of HBO therapy in this study\textsuperscript{9} remains dubious as other studies\textsuperscript{21,23–26} have reported successful osseointegration and function of DI in the absence of adjunct HBO therapy. The Visch study\textsuperscript{23} showed an inadequate ISR of DI (59\%) inserted in irradiated maxilla which was previously treated with HBO. In the study by Niimi et al.\textsuperscript{23} 169 mandibular implants and 59 maxillary implants were evaluated. For the mandible, the ISR was relatively high even when HBO had not been used. Results from this study\textsuperscript{23} suggested that DI can be placed in the irradiated mandibles in the absence of adjunct HBO therapy.

**Conclusion**

DI can osseointegrate and remain functionally stable in patients having undergone oral cancer therapy; however, such patients should be informed and consented in advance regarding complications associated with implant treatment following irradiation.

**Conflicts of interest statement**

None declared.

**References**


List of excluded studies. Main reason for exclusion is shown in parenthesis


