Outcomes of dental and craniofacial osseointegrated implantation in head and neck cancer patients

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Abstract

Background

Treatment of head and neck cancer may result in disfiguring and debilitating anatomical changes. Osseointegrated implants may be used in these patients to facilitate attachment of implant-retained dentures or cosmetic prostheses.

Methods

A retrospective audit was performed, reviewing the treatment of patients who received dental or craniofacial osseointegrated implants during treatment of head and neck cancer.

Results

160 implants were inserted in 54 patients with oral, nasal, orbital, or auricular defects. Overall, 85% of implants were successful after mean follow-up of 25.7 months. The brand of implant used was shown to impart a statistically significant implant survival difference, and orbital implants had poorer survival compared to non-orbital implants. There was a statistical insignificant implant survival advantage in both non-smokers and patients who did not undergo radiotherapy.

Conclusion

Dental and craniofacial osseointegrated implants may be reliably used in head and neck cancer patients. However, further research is required to clarify the role of smoking in osseointegrated implant failure.

Introduction

The treatment of head and neck cancer with surgery and radiotherapy can often result in debilitating and disfiguring anatomical changes. The loss of part of the maxilla, mandible, or dentition can limit speech and oral diet, while the loss of an ear, eye, or nose can leave patient with profound cosmetic changes. These functional and cosmetic changes can have deleterious effects on a patient's self-esteem and quality of life ⁽¹⁾. These changes can also make the fitting of conventional adhesive-based prostheses impractical and ineffective ^(2, 3). Osseointegrated implants were initially used in the non-cancer patient both in dental rehabilitation of the edentulous patient, and in the fixation of bone-anchored hearing aids. Subsequently, the use of these implants for dental or cosmetic rehabilitation following head and neck cancer has become common. Dental implants may be inserted into mandible, maxilla, or bony free-flaps to facilitate implant-retained dentures. Craniofacial implants may be inserted into the orbital rim, bones of the anterior nasal aperture, or the temporal bone to facilitate the attachment of prostheses.

While reported outcomes have been encouraging, the effects of smoking and radiotherapy on the success of implants have remained unclear. Cigarette smoking is a major risk factor for head and neck cancer ⁽⁴⁾ and the systemic effects of smoking have been implicated in failure of osseointegrated implants due to bone loss and peri-implantitis ⁽⁵⁻⁷⁾. Radiotherapy has been shown to cause changes to vascular and cartilaginous architecture, bone remodelling, and decreased bone thickness ^(8, 9). These histological changes would be expected to increase the failure rate of osseointegrated implants. Many retrospective clinical studies have supported this hypothesis ⁽¹⁰⁻¹²⁾, while others have shown no statistical difference in implant survival between irradiated and non-irradiated bone ^(2, 13, 14).

In this study, we aimed to report the success rate of both dental and craniofacial osseointegrated implants in head and neck cancer patients. Furthermore, we aimed to define the impact of radiotherapy, smoking, and chemotherapy on the success and failure of these implants.

Methods

A retrospective audit of patient records was performed of all patients who underwent placement of osseointegrated implants for dental and cosmetic rehabilitation after treatment of head and neck cancer at St. Vincent's Hospital, Melbourne, Australia. All implants were placed by the same oral surgeon between December 2010 and January 2018.

All implants were placed using a two-stage method. The first stage involved the placement of osseointegrated implants in the relevant native or free-flap bone. The relevant manufacturer-produced sequenced drills were used at low speed (800 revolutions per minute (rpm)) with irrigation to prepare the site for implant insertion. The insertion was then carried out at 15 rpm at a maximum of 45 Newton centimetres (Ncm) of torque. The implants were capped with healing abutments or closure caps. The second stage involved the exposure of implants under local or general anaesthetic, at the time soft-tissue modification if required was carried out to provide an appropriate platform for prosthesis placement.

(Figure 2, Figure 3)

Initial data was collected on patient demographics, surgical details, use of prostheses, and details of post-operative patient follow-up. Implants were placed for the attachment of dental prostheses in oral deficits, and for cosmetic prostheses in patients with nasal, orbital, and auricular deficits. Patients who were treated for head and neck cancer with either ablative surgical treatment or primary radiotherapy treatment were included. Patients were excluded

if they were lost to follow-up within six months of implant placement, or if available data for the patient was incomplete. Implant failure was defined as removal or loss of an implant for any reason; implant success was defined as an implant remaining *in situ* during the period of follow-up.

Institutional ethics approval was attained before the commencement of data collection.

Statistical analysis was completed using SPSS for Macintosh, version 25 (IBM Corp. Armonk, NY, USA). The Kaplan-Meier method was used to produce comparative survival curves, and the survival of implants in different groups were compared using the log-rank test, based on various parameters. A p value of < 0.05 was considered statistically significant.

Results

Patients

A total of 67 patients were identified for medical record review and data collection. 13 patients were excluded due to either incomplete data availability or time of follow-up of less than 6 months. Of the remaining 54 patients, 41 were males (75.9%) with a mean age at time of first implantation of 61.6 years. Other demographic data is summarised in Table 1. The mean dose of radiotherapy in irradiated patients was 62.7 Gray (Gy) (range 30 – 70Gy). All included patients had placement of osseointegrated implants following ablative surgery. No patients who underwent primary radiotherapy were included due to incomplete data or an insufficient period of follow-up. The primary pathology of included patients is summarised in Table 2, and includes two patients who underwent surgery for osteoradionecrosis after radiotherapy for head and neck malignancy. 28 (51.9%) patients had osseointegrated implants placed for an oral defect, 13 (24.1%) patients had a nasal defect, 11 (20.4%) had an orbital defect, one patient (1.9%) had an auricular defect, and one patient (1.9%) had implants placed for a complex oral, nasal, and orbital defect. 42 patients (77.8%) had proceeded to a stage 2 procedure for exposure of implants and placement of abutments at the time of latest follow-up. Abutments were not exposed in cases of early disease progression, poor patient health precluding further procedures under general anaesthetic, or persistent post-operative wound complications that precluded further soft-tissue remodelling. More recent patients were yet to undergo a stage 2 procedure at the time of latest follow-up, but were expected to do so in the future. 35 patients (64.8%) were fitted with a prosthesis; 28 with oral defects (51.9%), 13 with nasal defects (24.1%), 11 with orbital defects (20.4%), and one patient with each of auricular and complex oral/nasal/orbital defects (100%). Patients who were not fitted with a prosthesis

included those who had not undergone a stage 2 procedure as detailed above, patients with implant failure, and patients who elected to not have a prosthesis fitted. 30 patients (55.6%) implants placed at the time of resection, 20 patients (37%) had the placement of implants delayed until after radiotherapy, and four patients (7.4%) had implants placed both at the time of resection and after radiotherapy.

18 patients underwent bone free-flap reconstruction (33.3%), all for oral defects; 14 with fibula free flap (25.9%), and four with deep circumflex iliac artery flap (7.4%). None of the included patients were treated with hyperbaric oxygen.

Patients were followed-up as outpatients for a mean of 25.7 months (range, 6 – 89 months). In this time, eight patients died either of cancer-related or other causes. Patients who underwent radiotherapy were followed up for a mean of 27 months, while those who did not undergo radiotherapy were followed-up for 18.3 months.

Implants

A total of 160 osseointegrated implants were placed in the 54 patients. Overall, 136 implants were successful, giving a success rate of 85%. The mean time to implant failure was 20.2 months (range, 1.5 – 48 months). Implants produced by two companies were used in this study: 143 Institut Straumann AG (Basel, Switzerland) implants (78 oral, 31 nasal, 27 orbital, five nasal/oral, and two auricular, 89.4% of total implants), and 17 Cochlear Vistafix (Gothenburg, Sweden) implants (nine orbital, eight nasal, 10.6% of total implants). The Straumann implants had a significant implant survival advantage ($p < 0.05$) with 130 implants successful (90.9%) compared to six of the Cochlear implants (35.3%) (Figure 4). 37 implants (23.1%) were not exposed in Stage 2 procedures.

The distribution of implants by anatomical site is summarised in Table 3. Orbital implants had statistically significantly poorer survival when compared to non-orbital implants ($p < 0.05$). There was no statistically significant difference in implant survival between oral and craniofacial implants ($p = .241$), nor nasal and non-nasal implants ($p = .686$). 122 implants were placed in native bone of which 104 were successful (85.2% success), and 38 implants were placed in bone free-flaps of which 32 were successful (84.2% success). The implant survival difference between the two groups was not statistically significant ($p = .890$).

Similarly, when only implants placed in oral defects were compared, there was no survival difference between implants in native bone (40 implants, 87.5% success) and bone free-flaps (38 implants, 84.2% success) ($p = .489$).

138 implants were placed in patients who underwent radiotherapy with success in 110 (82.6% success), compared with 24 implants placed in those who did not undergo radiotherapy with success in all implants (100% success). Of these 138 implants placed in patients who underwent radiotherapy, 74 were placed before radiotherapy with success in 61 implants (82.4% success), and 64 placed after radiotherapy with success in 53 implants (82.8% success). There was a statistically insignificant trend towards improved implant survival for non-irradiated implants as compared to irradiated implants ($p = .090$) (Figure 6). There was no implant survival difference between insertion of implants pre-radiotherapy and insertion of implants post-radiotherapy groups ($p = .919$) (Figure 7). There was no significant implant survival difference between implants placed in irradiated native bone (109 implants, 83.5% success) and irradiated bone free-flap (29 implants, 79.3% success) ($p = .919$). There was no significant implant survival difference between irradiated and non-irradiated patients in either of the oral implant (63 irradiated implants with 82.5% survival, 15 non-irradiated implants with 100% survival; $p = 0.194$) (Figure 8) or nasal implant groups (32 irradiated

implants with 87.2% survival, seven non-irradiated implants with 100% survival; $p = 0.26$) (Figure 9). All 36 orbital implants were irradiated, and both the auricular and nasal/oral groups had insufficient n values for substantial analysis. None of the failed implants were associated with osteoradionecrosis (ORN).

There were 47 implants placed in patients who underwent chemotherapy, with a success rate of 80.9% compared to 86.7% in implants placed in patients who did not undergo chemotherapy. There was no significant difference in implant survival between the two groups ($p = .702$).

82 implants were placed in current smokers (51.2%), 32 in ex-smoker (20%), and 46 in non-smokers (28.8%). The implant success rates in these groups was 84.1%, 78.1%, and 91.3% respectively. Although there was a trend towards an implant survival advantage in non-smokers, this was not statistically significant ($p = .241$). Similarly, there was a statistically insignificant trend towards a survival advantage for implants placed in non-smokers when compared to the two smoking groups combined ($p = .108$). (Figure 10).

100 implants were loaded with a prosthesis with an 83% success rate, and 60 implants were not loaded with a prosthesis with an 88.3% success rate. There was no significant implant survival between the two groups ($p = .275$).

Discussion

This study examined the outcomes of 160 osseointegrated implants inserted for dental and cosmetic rehabilitation after the treatment of head and neck cancer in 54 patients. After a mean follow-up period of 25.7 months, the overall survival rate was 85%. The brand of implant used was shown to impart an implant survival advantage (Figure 4) and orbital implants had significantly poorer outcomes than implants placed in non-orbital locations. Statistically insignificant trends towards implant survival advantage were seen in both non-smokers and patients who did not undergo radiotherapy. Chemotherapy, the placement of implants in bone free-flaps, and the insertion of implants either before or after radiotherapy were not shown to be statistically significant factors in the survival of osseointegrated implants.

The success rates of oral, nasal, and orbital implants separately are similar to those previously described in comparable studies. Oral implants in the current study have a success rate 85.9%, compared to 77 - 98.6% in head and neck cancer patients in comparable studies^(11, 13, 15-21). Nasal implants in the current study had a success rate of 87.2%, compared to previously described success rates of 75 - 100%^(2, 10, 12, 22, 23). Orbital implants in the current study had a success rate of 77.7%, which is similar to the 73.2% - 82.4% success rate described in most comparable studies^(12, 14, 22-25), but lower than the success rates of 94.5% and 100% described by Greig *et al.*⁽²⁶⁾ and Curi *et al.*⁽¹⁰⁾ respectively. It should be noted that 80.8% of oral implants, 82.1% of nasal implants, and 100% of orbital implants were placed in irradiated bone. These percentages are higher than those described in any of the other aforementioned studies. The auricular and nasal-oral implants had insufficient numbers to substantively compare to other studies.

The poorer outcomes observed in orbital implants is in keeping with previously described observations in the literature. Abu-Serriah *et al.*⁽²⁵⁾, Karakoca *et al.*⁽²²⁾, and Woods *et al.*⁽¹²⁾ all described poorer outcomes of orbital implants as compared to other craniofacial implants in their respective studies on extraoral osseointegrated implants. Although the exact mechanism for poorer survival of orbital implants is unclear, the aforementioned studies suggest relatively poor blood supply and poor quality and volume of orbital rim cortical bone, and difficulties in patients maintaining adequate hygiene as possible contributing factors. In the current study, the increased rate of radiotherapy (100% of orbital implants were irradiated) must be considered as contributing to poorer implant survival outcomes. As 52.9% of Cochlear implants were placed for orbital defects as compared to 18.9% of Straumann implants, the poorer implant survival of orbital implants may also be contributing to the observed difference between the two brands.

The effects of radiotherapy on the survival of osseointegrated implants has been studied extensively. A previously published systematic review of the literature demonstrated a higher rate of both dental and craniofacial implant failure in irradiated bone, albeit from poor-to-moderate data⁽²⁷⁾. In the current study, we found a statistically insignificant implant survival advantage in implants placed in non-irradiated bone across all anatomical sites ($p = 0.09$) (Figure 6). Similarly, there is a clear separation of Kaplan-Meier curves between implants in irradiated and non-irradiated groups in both oral and nasal implants separately, without a statistically significant difference ($p = 0.194$ and $p = 0.26$, respectively) (Figure 8, Figure 9). The lack of statistical significance may be partially attributed to a shorter period of follow-up in the non-irradiated group – a mean of 18.3 months in non-irradiated patients compared with 27 months in irradiated patients. Many patients treated for head and neck cancer at St Vincent's are referred from regional and interstate hospitals. If deemed appropriate at the

completion of their treatment, these patients may be referred back to these hospitals for long-term follow-up with local surgeons, dentists, and prosthetists for patient convenience and to save on travel and accommodation expenses. Patients who do not require post-operative radiotherapy as a part of their treatment were likely to have less severe initial disease staging, a less significant resection and reconstruction, and are therefore more likely to be appropriate for long-term follow-up at peripheral hospital rather than at a subspecialist head and neck cancer outpatient clinic. In this manner, patients in this study who did not undergo radiotherapy may be lost to follow-up at an earlier time than those undergoing radiotherapy.

In the non-head and neck cancer patient population, cigarette smoking has been shown to increase the risk of dental osseointegrated peri-implantitis, marginal bone loss, mucositis, and implant failure ^(5, 28-31). In the head and neck cancer patient population, cigarette smoking has been shown to increase risk of osteoradionecrosis after oral implant placement ⁽¹⁵⁾, and increase the risk of peri-implant skin reaction in temporal bone implants for auricular defects ⁽³²⁾. In the current study, we found that implants placed in non-smokers had a statistically insignificant implant survival advantage when compared to smokers (ex-smokers, and current smokers combined) ($p = .108$) (Figure 10). Karayazgan-Saracoglu *et al.* found a similar statistically insignificant trend towards implant survival advantage for craniofacial implants in non-smokers ($p = 0.07$) ⁽²³⁾, while both Woods *et al.* ⁽¹²⁾ and DeSerres *et al.* ⁽¹⁴⁾ found no difference in craniofacial implant survival between smokers and non-smokers. Given the high rate of tobacco use amongst head and neck cancer patients, further research is required to define the role of cigarette smoking in osseointegrated implant survival in these patients.

A relatively low number of patients were fitted with prostheses in the current study, 64.8% as compared to 80 - 93.5%^(15, 16, 19) for comparable studies in dental osseointegrated implants, and 100%^(10, 32) for comparable studies in craniofacial osseointegrated implants. This is partially due to the study design of other reports excluding patients with incomplete rehabilitation, and the current study including patients who were yet to complete planned fitting of prostheses at the time of last follow-up. The low rate of prosthetic use in the current study may cause the true rate of implant loss to be underestimated, as implants not loaded with a prosthesis are not subjected to the same mechanical forces as those that are loaded with prostheses.

The inherent bias of retrospective data collection and a relatively short mean period of follow-up of 25.7 months are the most obvious limitations of this study. Several patients were excluded due to incomplete data sets which may have been avoided if patients had been prospectively recruited, monitored, and actively followed-up after the placement of implants. The observed difference between brands of osseointegrated implants must be read with caution given the disparity in experience and volume the operating surgeon had with each brand, and the difference in usage rates of each of the brands in different anatomical regions.

Conclusion

The use of osseointegrated implants is a reliable method of cosmetic and dental rehabilitation in head and neck cancer patients. Radiotherapy and smoking may increase the risk of implant loss, but overall implant survival rates still remain at 85%. Further research is required to illuminate the role of cigarette smoking in osseointegrated implant failure given the high rates of tobacco use in this patient population.

Tables and figures

Table 1: patient demographics (abbreviation - Gy = Gray)

Demographic	Number of patients
Gender	41 males (75.9%)
Mean age at time of first implant insertion	61.6 years
Smoking	
non-smoker	17 patients (31.5%)
current smoker	25 patients (46.3%)
ex-smoker	12 patients (22.2%)
Diabetes mellitus	3 patients (5.6%)
Radiotherapy	46 patients (85.2%)
mean dose	62.76 Gy
Chemotherapy	16 patients (26.9%)

Table 2: frequency of primary pathology within the patient population

Pathology	Number of patients with each pathology
Squamous cell carcinoma	39 (72.2%)
Adenoid cystic	6 (11.1%)
Melanoma	2 (3.7%)
Osteoradionecrosis	2 (3.7%)
Basal cell carcinoma	1 (1.9%)
Mucoepidermoid carcinoma	1 (1.9%)
Nerve sheath sarcoma	1 (1.9%)
Neuroendocrine carcinoma	1 (1.9%)
Sebaceous carcinoma	1 (1.9%)

Table 3: number and percentage of implants placed in anatomical sites, rate of implant success for each site, and the percentage of implants at each site placed in bone before or after radiotherapy.

Defect	Number of implants	Number of successful implants	Percentage of implants in irradiated patients
Oral	78 (48%)	67 (85.9%)	80.8%
Nasal	39 (24.4%)	34 (87.2%)	82.1%
Orbital	36 (22.5%)	28 (77.7%)	100%

Nasal/oral	5 (3.1%)	5 (100%)	100%
Auricular	2 (1.3%)	2 (100%)	100%

Figure 1: Post-operative orthopantomogram showing two osseointegrated implants in each of native mandible and fibula free-flap.

Figure 2: osseointegrated implant-based reconstruction after total rhinectomy. Image A: intraoperative placement of implants in anterior nasal aperture. Image B: After stage 2 – exposure of implants and remodelling of peri-implant soft tissue. Image C and D: After completion of reconstruction, with and without prosthesis *in situ*.

Figure 3: osseointegrated implant-based reconstruction after orbital exenteration. Image A: intraoperative placement of implants in orbital rim. Image B: After stage 2 – exposure of implants and remodelling of peri-implant soft tissue. Image C and D: After completion of reconstruction, with and without prosthesis *in situ*.

Figure 4: Implant survival according to implant brand. Straumann implants had a significant implant survival advantage over Cochlear implants ($p < 0.05$).

Figure 5: implant survival according to site – orbital implants compared to non-orbital implants. Non-orbital implants had a significant survival advantage over orbital implants

Figure 6: implant survival according to irradiation. Although there is clear separation of the survival curves, the implant survival difference between the two groups is not statistically significant ($p = 0.09$)

Figure 7: Implant survival according to timing of radiotherapy. There was no survival difference between implants inserted before and after radiotherapy ($p = .919$).

Figure 8: oral implant survival according to irradiation. Although there is clear separation of the survival curves, the implant survival difference between the two groups is not statistically significant ($p = .194$)

Figure 9: nasal implant survival according to irradiation. Although there is clear separation of the survival curves, the implant survival difference between the two groups is not statistically significant ($p = .26$).

Figure 10: Implant survival according to smoking status. The smokers category includes both current and ex-smokers. A statistically insignificant difference is seen between the two groups ($p = .108$).

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