Factors Affecting Survival and Usefulness of Implants Placed in Vascularized Free Composite Grafts Used in Post–Head and Neck Cancer Reconstruction

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ABSTRACT

Background: Bone-containing vascularized grafts have been used successfully to reconstruct post-cancer surgical defects. Dental implants can be placed in these bone-containing grafts to allow implant-supported prosthodontic reconstruction of these patients.

Purpose: The aim of this study was to evaluate the survival of dental implants used in the rehabilitation of subjects treated with bone-containing vascularized grafts to compare usability of implants placed at the time of reconstruction and after healing.

Materials and Methods: A cross-sectional study was undertaken to examine survival rates of implants placed in vascularized bone-containing grafts either immediately at the time of surgical reconstruction or after 3 months healing. Other factors such as graft type, whether radiation therapy was given, and implant type were recorded.

Results: A total of 41 patients had 145 implants placed in 47 vascularized bone-containing flaps. Increased failure rate of implants was seen in immediately placed implants. There was also a significant increase in the number of osseointegrated implants that were prosthodontically unusable or sub-optimally placed in the immediate placement group. Radiation therapy was associated with a significant increase in failure rate. Modern implant surfaces appeared to perform better than machined/turned surfaces. Graft donor site did not influence implant survival.

Conclusion: This study demonstrated the difficulties encountered with immediate placement of dental implants at the time of post-cancer reconstructive surgery.

KEY WORDS: dental implants, mouth neoplasm, oral rehabilitation, radiotherapy, radiotherapy adverse events

INTRODUCTION

Surgical treatment of head and neck cancers may result in facial disfigurement which may result in psychological, social, and functional impairment with adverse effects on quality of life.[1,2] The use of prosthetic obturators to restore form and function after partial maxillectomy is a long-standing treatment modality, but these prostheses are associated with marked measurable adverse effects on quality of life.[1] Obturators replacing defects involving posterior teeth and extending to or beyond the ipsilateral canine are associated with reduced retention and stability, impaired mastication, and compromised speech.[3] Obturation of defects involving the zygoma or orbital rim usually result in poor aesthetic

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results.[4] Initially, soft tissue flaps were used to close palatal defects[5] but while oro-nasal communication could be eliminated, these flaps were prone to sagging and precluded the use of dentures or implants to replace missing teeth.

In the past where mandibular resections have caused discontinuity of the mandible, these defects have not been restored, resulting in major deformity and loss of function. Vascularized bone-containing free flap reconstruction has been shown to be reliable and is now routinely employed in some specialist head and neck cancer centers to reconstruct these defects.[6] They have been shown to improve rehabilitation significantly in comparison to non-reconstruction of similar mandibular defects.[7]

Vascularized bone-containing free flap reconstruction is also employed to reconstruct palatomaxillary defects and has been associated with improved function and quality of life.[4,8] Immediate reconstruction of surgical defects avoids psychological trauma of having a defect and may preserve function and may better reconstruct form and appearance.

An additional benefit of placing bone-containing composite free flaps is the possibility of placing dental implants.[9] Dental implants placed in a vascularized grafted bone display levels of survival not markedly less than those seen in routine dental situations.[10] Radiotherapy has been shown to influence survival of dental implants adversely by some researchers[11,12] but not by others.[13,14] In order to minimize the effects of radiotherapy on osseointegration some authors have proposed immediate reconstruction of surgical defects with vascularized composite grafts and immediate placement of implants, allowing osseointegration to commence during the post-surgery healing phase prior to the commencement of radiotherapy. This approach has been shown to result in improved osseointegration rates and implant survival.[11] However, other authors have found contradictory results.

At Guy's and St Thomas's Hospitals (London, United Kingdom), the specialist head and neck cancer unit now treats approximately 480 new patients a year, of whom about 30 require prosthodontic intervention involving placement of implants in vascularized composite flaps. Patients have been treated with either immediate placement of implants at the time of surgical reconstruction or delayed placement, usually 3 months after grafting. Implants are not placed in bone irradiated to 66 Gy, the usual therapeutic dose at this center. Because of previous experience of high failure rates and osteoradionecrosis, implants are not placed in previously fully irradiated (66 Gy) bone.

A case has been made for immediate placement of implants at the time of grafting, based on streamlining the treatment process, reducing the number of surgical interventions and having implants in place before radiotherapy, as this has been shown to increase implant survival to acceptable levels.[11] The alternative approach of placing implants 3 months after grafting is justified by the argument that implants can be placed in a conscious, cooperative patient after further prosthodontic planning to construct stents to ensure optimal implant orientation. There is a possibility that graft survival might also be adversely affected by immediate implant placement.

The aim of this study was to compare survival and usability of dental implants placed at the time of grafting/reconstruction and implants placed after a delay of 3 months in healed successful grafts.

The primary hypothesis to be tested was that there was no difference in survival between immediate or delayed placement of dental implants in vascularized composite grafts.

MATERIALS AND METHODS

Ethical approval was granted by the Guy's Hospital Research Ethics Committee for a cross-sectional study to investigate survival rate of dental implants placed as part of post-cancer reconstructions. Inclusion criteria were that patients had implants placed in vascularized grafts placed to reconstruct post-cancer defects. Only patients who had implants placed at least 3 years previously were included. Potential subjects were provided with an account of the proposed research and a patient information sheet at the initial visit. Written consent was obtained from all patients willing to participate at the next visit, usually 7–14 days later.

Information recorded included type of graft employed, location of graft, number of implants, location of implants, type of implant used, timing of implant placement (immediate or delayed), and specialty of surgeon placing implants (consultant in maxillofacial surgery or consultant in restorative dentistry). Success or failure of osseointegration was recorded in addition to usefulness of implants. The following four-point scale was used: 1, failure of osseointegration; 2, implants osseointegrated in positions or at angulations

that rendered them prosthodontically unusable; 3, suboptimally oriented implants (osseointegrated implants that though prosthodontically usable, resulted in screw holes emerging outside occlusal surfaces of posterior teeth or palatal or lingual surfaces of anterior teeth); 4, well-oriented implants (osseointegrated implants with screw holes emerging through occlusal surfaces of posterior teeth or palatal or lingual surfaces of anterior teeth). Only screw-retained prostheses were used because of the need to be able to remove prostheses for regular preventive oncology surveillance.

Data were retained in an Excel database and were analyzed using Stata 9.0. As data were categorical, contingency tables were analyzed using Pearson's χ^2 or Fisher's exact test. The appropriate multivariate analysis for categorical data, Multiple Correspondence Analysis (MCA), was undertaken.

RESULTS

A total of 145 implants were placed in 47 bone grafts in 41 patients. In addition, 56 implants were placed in residual mandibular or maxillary bone. None of the latter failed and all were optimally placed. In none of these cases was the bone subjected to substantial doses of radiotherapy.

Twelve patients received implants by immediate insertion into vascularized grafts which were subsequently subjected to therapeutic doses of radiotherapy (66 Gy). Radiotherapy was significantly associated with failure of osseointegration in grafted bone (Table 1). When analysis was undertaken by patient rather than by implant, radiotherapy was still significantly associated with failure (Table 2). All 18 implant osseointegration failures happened in the 6 months between implant placements and loading with prostheses. No implants failed in service in the subsequent 30 months or lost substantial amounts of attachment. This precluded the use of meaningful cumulative survival rate calculations, as implant failures before prosthesis placement probably represent failure to osseointegrate rather than failure of oseointegration.

TABLE 1 Survival of Implants in Irradiated and Non-Irradiated Bone

	Failure to Osseointegrate	Osseointegration	Total
No radiotherapy	3	107	110
Radiotherapy	15	20	35
Total	18	127	145

Pearson $\chi^2 = 39.33$; degrees of freedom = 1; $p < .001$. Fisher's Exact Test: $p < .001$.

There was no significant difference in the survival rate for implants placed by maxillofacial surgeons and restorative dentistry consultants in grafts that were not irradiated (Table 3).

In free vascularized grafts not subjected to radiotherapy, maxillofacial surgeons were responsible for all of the implants placed immediately (60 implants) and for 15 implants placed 3 months after grafting. In contrast, restorative dentistry consultants placed 35 implants 3 months after grafting.

Survival of immediately placed implants was significantly worse than for implants placed after a delay of 3 months in free vascularized grafts (Table 4).

Immediately placed implants were significantly less well-oriented and therefore less useful than implants placed after a delay of 3 months in free vascularized grafts (Table 5).

Implants with modern micro-roughened surfaces possibly survived better than those implants machined

TABLE 2 Survival by Patient of Implants in Irradiated and Non-Irradiated Bone

	Failure of Osseointegration in One or More Implants	Osseointegration of All Implants	Total
No radiotherapy	2	27	29
Radiotherapy	8	4	12
Total	10	31	41

Fisher's Exact Test: $p < .001$

TABLE 3 Comparative Survival of Implants Placed by Maxillofacial Surgeons and Restorative Dentistry Consultants in Free Vascularized Grafts Not Subjected to Radiotherapy

	Maxillofacial Surgeons	Restorative Dentistry Consultants	Total
Failure to osseointegrate	3	0	3
Osseointegration	72	35	107
Total	75	35	110

Pearson $\chi^2 = 1.44$; degrees of freedom = 1; $p = .23$. Fisher's Exact Test: $p = .55$.

or macro-roughened when placed in grafted bone that was not irradiated (Table 6).

No significant difference was found between survival rates of implants in vascularized grafts harvested from different donor sites (Table 7).

MCA was undertaken. This powerful multivariate method is the appropriate approach for categorical data. In a similar fashion to Pearson's χ^2 which examines distribution of the χ^2 statistic in a two-dimensional contingency table, MCA examines distribution of the χ^2 statistic in a theoretical multidimensional contingency table. The partition of the χ^2 statistic involved in correspondence analysis permits the greatest amount of the total χ^2 (referred to as χ^2 inertia) to be plotted preferentially on the first and second axes and on subsequent axes in ever decreasing amounts of χ^2 inertia. Thus, later axes capture trivial amounts of the χ^2 inertia. Graphical representation of the correspondence analysis involves a choice of axes on which to plot points representing the rows and columns of the multi-way contingency table. The graphical representation must involve only two true dimensions.

Figure 1 shows the MCA plot of implant survival, implant usefulness, surgeon, radiotherapy, timing, graft type, and implant type.

Interpretation of the Plot – Multivariate Findings

There is a close correspondence among implant survival, absence of radiotherapy, and use of Astra implants.

TABLE 4 Comparative Survival of Implants Using Immediate Placement or Delayed Placement in Free Vascularized Grafts

	Failure to Osseointegrate	Osseointegrated but Unusable	Osseointegrated Suboptimal	Osseointegrated in Good Position	Total
Immediate Placement	18	16	28	33	95
Delayed Placement	0	0	2	48	50
Total	18	16	30	81	145

Pearson $\chi^2 = 50.18$; degrees of freedom = 3; $p < .001$. Fisher's Exact Test: $p < .001$.

TABLE 5 Comparative Survival of Implants Using Immediate Placement or Delayed Placement in Free Vascularized Grafts Not Subjected to Radiotherapy

	Failure to Osseointegrate	Osseointegrated but Unusable	Osseointegrated Suboptimal	Osseointegrated in Good Position	Total
Immediate Placement	3	13	22	22	60
Delayed Placement	0	0	2	48	50
Total	3	13	24	70	110

Pearson $\chi^2 = 41.76$; degrees of freedom = 3; $p < .001$. Fisher's Exact Test: $p < .001$.

TABLE 6 Survival of Different Implant Types in Free Vascularized Grafts Not Subjected to Radiotherapy

	Failure to Osseointegrate	Osseointegration	Total
Nobel Biocare Machined	2	32	34
Endopore	1	7	8
Astra	0	68	68
Total	3	107	110

Pearson $\chi^2 = 6.06$; degrees of freedom = 2; $p < .001$. Fisher's Exact Test: $p = .034$.

DISCUSSION

The primary hypothesis that there was no difference in survival and usability between immediate or delayed placement of dental implants in vascularized composite grafts was not supported by the results of this study. The logic behind primary placement of implants in vascularized grafts is twofold: to reduce procedure time for patients and secondly to place implants enough in advance of radiotherapy to permit osseointegration. A total of 18 implants failed and all were immediately placed. All failed before the final prostheses placement. Another cause for concern relates to the number of unusable or poorly placed osseointegrated implants. All of the unusable and all but two of the sub-optimally oriented implants were placed immediately at the time of surgical reconstruction. This emphasizes the difficulties of correct implant placement in circumstances when guidance stents cannot normally be used and where anatomical landmarks have been lost due to replacement of normal anatomy with grafted bone and the frequent presence of excessive amounts of soft tissues associated with the newly placed vascularized graft.

TABLE 7 Survival of Implants in Different Types of Free Vascularized Grafts Not Subjected to Radiotherapy

	Failure to Osseointegrate	Osseointegration	Total
DCIA	3	76	79
RFF onlay	0	18	18
Fibula	0	s10	10
Rib	0	3	3
Total	3	107	110

Pearson $\chi^2 = 1.21$; degrees of freedom = 3; $p = .75$. Fisher's Exact Test: $p = 1.0$.

Two of the three implants that failed to osseointegrate in the non-irradiated group were in one patient, located in a composite graft that had been sectioned into four bone block sections, and plated to provide a curved mandibular profile. Five implants were immediately placed in three of the sections. The single block which contained the two implants subsequently was sequestered. One could speculate that the bony section of the graft may have been non-vital from the time of placement or that placement of implants in the grafted block of bone may have compromised the vitality of the block. Yerit and colleagues.[12] previously found reduced survival rates for implants placed in grafted tissue. However, apart from the aforementioned case, this finding was not generalized for other patients in this study.

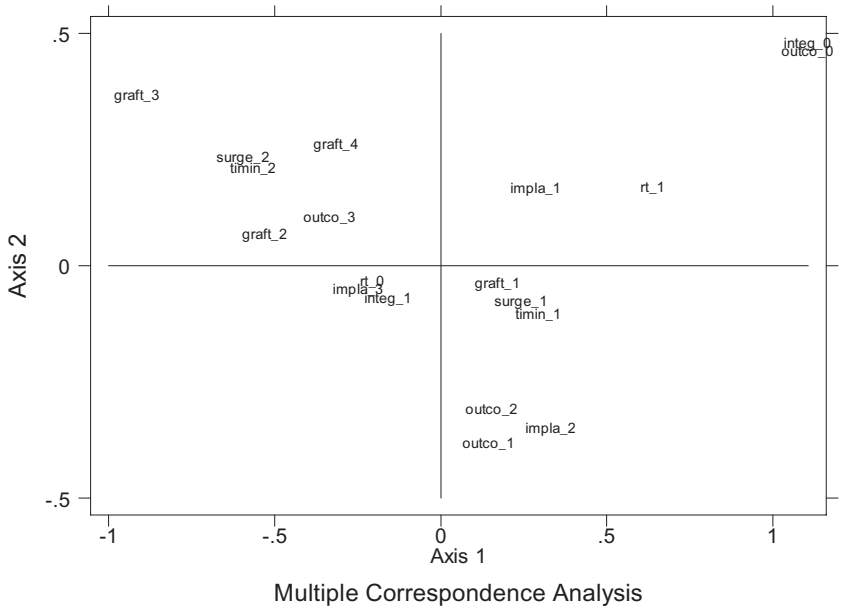
Twelve patients had implants placed in grafted bone prior to irradiation and eight of these patients subsequently lost one or more implants. Osteoradionecrosis was seen in three patients, one of whom lost a complete graft to osteoradionecrosis in increments over 12 months, losing all four implants present, another lost two of four implants in part of a graft affected by osteoradionecrosis, and the third lost one of three implants. The finding of osteoradionecrosis in association with dental implants contradicts previous findings.[15] A total of 15 implants were lost in grafted sites irradiated to 65 Gy. Other authors[13] found a non-significant reduction in survival of implants placed in irradiated tissues. However these authors described as irradiated, tissues that had received radiation doses as low as 10 Gy, therefore radiation doses were not comparable.

Modern implant surfaces appeared to perform better than older machined or macro-roughened surfaces. However, the numbers were small, thus it would not be wise to draw definite conclusions from this sample.

That no significant differences were found between the survival rates for implants placed in different graft donor sites is in line with clinical experience.

CONCLUSIONS

There was a high failure rate of implants placed immediately at the time of reconstructive surgery with vascularized bone-containing grafts. Over a fifth of immediately placed implants that osseointegrated were unusable and another third were sub-optimally placed. It can be



Total inertia : 0.175

Principal Inertia Components :

	Inertia	Share	Cumulative inertia
Dimension 1	0.147	0.839	0.839
Dimension 2	0.026	0.148	0.986

Number of axes = 6.

Note: the point plotted is in the center of each label.

Figure 1 Multiple correspondence analysis plot of implant survival, implant usefulness, surgeon, radiotherapy, timing, graft type, and implant type. Key: rt_0 = no radiotherapy; rt-1 = radiotherapy (66 Gy); integ_0 = implant failed; integ_1 = implant survived; surge_1 = MaxFac surgeon; surge_2 = Restorative Dentist; impla_1 = Nobel Biocare; impla_2 = Endopore; impla_3 = Astra; outco_0 = implant failed; outco_1 = implant survived but useless; outco_2 = implant survived but sub-optimally placed; outco_4 = implant survived and well placed; graft_1 = DCIA; graft_2 = RFF; graft_3 = Fibula; graft_4 = Rib.

concluded from this study that it is difficult to optimize implant positioning for prosthodontic reconstruction in vascularized bone-containing grafts used to reconstruct post-cancer defects if the implants are placed immediately at the time of primary reconstruction.

Almost a third of the implants placed in vascularized bone containing grafts that received a therapeutic dose of radiation (65 Gy) failed.

Donor sites for vascularized bone-containing grafts did not influence implant survival.

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