# Dental Implants in Radiated Fibula Free Flaps: A Systematic Review

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## ABSTRACT

**Introduction**
Dental rehabilitation in irradiated patients with free flap reconstruction is a challenge given wound healing difficulties and concern for osseointegration in devascularized tissues. Current studies cite success rates anywhere from 38-90% in irradiated patients; however, these percentages are derived from small, largely retrospective chart reviews. Given that the quality of life in head and neck patients is greatly diminished after treatment when dental rehabilitation is little to nonexistent, we sought to examine the available literature and propose a treatment algorithm based on these findings.

**Methods**
The protocol was registered and accepted with the systematic review database, PROSPERO (CRD42022372499) . Our inclusion criteria were studies that discussed osseointegrated dental implants placed into fibula free flaps in patients with a history of radiation. This included adjuvant radiation following primary surgical resection, history of either primary radiation with surgical salvage for persistence or recurrence, or history of prior radiation with resultant osteoradionecrosis as the indication for free flap.

**Results**
There were 14 studies that met the criteria for inclusion. 8 out of 14 were retrospective chart reviews, 4 were pilot studies detailing protocols for implantation, and the remaining two were a case series and case report. On pooled analysis, a total of 415 dental implants were placed in 148 patients. We noted an overall survival rate, defined as successfully osseointegrated implants, of 74% (308/415). At 6 months post-surgery, the survival rate was 86% (284/330). Only 5 of the 14 studies provided comparative data between RT vs no RT, 2 reported no difference and 3 did report statistically significant worse outcomes in patients with RT; however, no articles provided enough data to run pooled statistical analysis. 5 out of 14 studies discussed the use of hyperbaric oxygen, with an overall survival rate of 69.8% (125/179; p = 0.075). 13 out of the 14 studies reported timing of implant placement, either immediate at the time of surgery or delayed after a period of healing. Immediate implants had an overall survival of 93.9% (62/66) and delayed of 74.5% (182/244). Immediate placement was associated with better overall survival (p=<0.001).

**Conclusions**
Despite limitations we were able to conclude that a history of radiation does appear to decrease survival rates for dental implants placed into fibula free flaps. The data on hyperbaric oxygen remains controversial. An unexpected finding was that immediate placement does appear to improve survival; however, data on timing of radiation is still lacking. Our hope is that our paper serves as a catalyst for larger, perhaps multi-institutional or prospective research on this topic.

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## INTRODUCTION

Dental rehabilitation in irradiated patients with free flap reconstruction is a challenge given concern for osseointegration. Current studies cite success rates from 38-90%; however, these percentages are derived from small, largely retrospective chart reviews. Given that the quality of life in these patients is greatly diminished when dental rehabilitation limited, we sought to systematically review the available literature.

**PRIMARY AIM**
- Survival of osseointegrated dental implants placed in fibula free flap (FFF) reconstructions in the setting of history of radiation (RT)

**SECONDARY AIMS**
- Factors influencing survival
- Rates of long-term complications

## METHODS AND MATERIALS

The protocol was registered and accepted with PROSPERO. Our search study utilized three databases: Medline, Scopus, and Cochrane. MeSH terms + entry terms + keywords were “fibula free flap”, “dental implants”, and “radiation therapy.” Articles were selected based on the following criteria:

**Inclusion criteria:**
- osseointegrated dental implants placed into fibula free flaps in patients with a history of radiation
- those with adjuvant radiation following primary surgical resection
- history of either primary radiation with surgical salvage for persistence or recurrence
- history of prior radiation with resultant osteoradionecrosis as the indication for free flap

**Exclusion criteria:**
No history of radiation
- Reconstructions besides fibula free flaps
- Implants placed in native bone
- Language other than English

Quality of reviewed articles was assessed with the MINORs score, where 16 is the ideal score for non-comparative studies; our articles averaged 8.9.

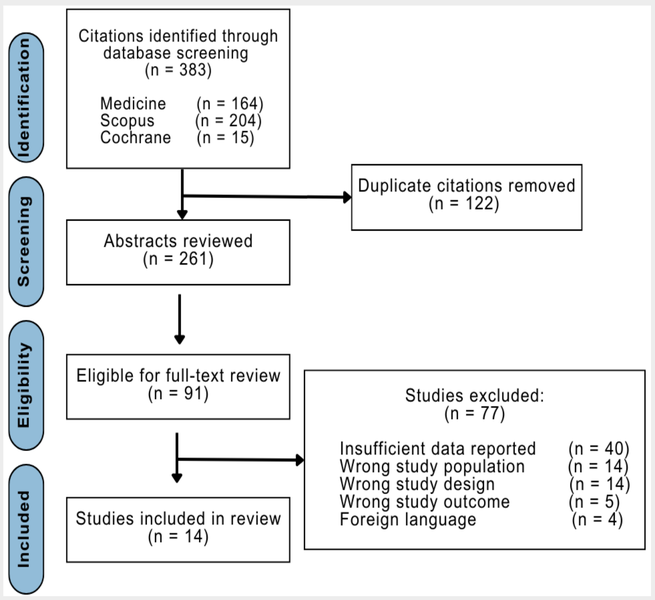


**Image 1:** Database search yielded 383 articles, 14 of which were included for review based on inclusion and exclusion criteria.

## RESULTS

| | | |
|---|---|---|
| Total patients (N) | 148 | |
| Total implants (n) | 415 | |
| Implants placed pre-RT (n) | | 32 |
| Implants placed post-RT (n) | | 209 |
| Implants placed into radiated field (n) | | 114 |
| Irradiation status unknown (n) | | 60 |
| Total implants failed (n/%) | 107 (25.8%) | |
| Total implants survived (n/%) | 308 (74.2%) | |
| At 6 months | | 284 / 330 (86.1%) |
| Timing of Implant Placement (# implants) | | |
| Immediate | | 66 |
| Delayed | | 336 |
| Unknown | | 13 |
| Hyperbaric oxygen tx | 5 / 14 studies | 52 / 78 patients |

**Table 2.** Implant Data

A total of 415 dental implants were placed in 148 patients. Only two studies described reconstruction of the maxilla, and the rest were mandibular reconstruction. Half (209/415) were placed after completion of RT in the setting of primary surgery followed by adjuvant RT. The majority of implants were placed in a delayed fashion, anywhere from months to years later. 66 (16%) of the implants were placed into fibula bone immediately at the time of reconstruction.

We noted an overall survival rate of 74%., with 86% at 6 months. The articles that provided more longitudinal data at 5 – 10 years did show a trend to lower survival rates over time.

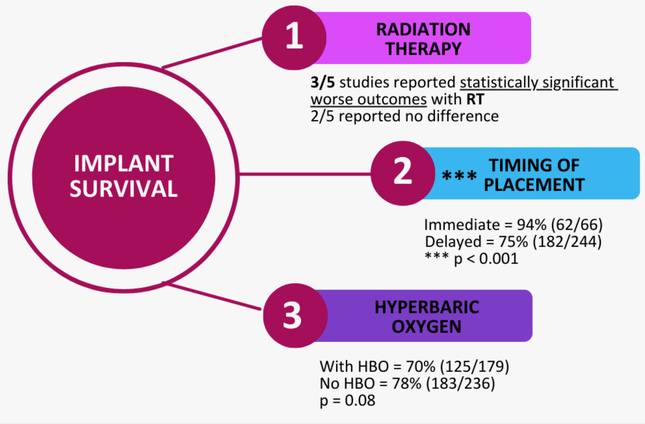


**Image 2:** Factors Influencing Implant Survival

**Table 1. Characteristics of included publications**

| Authors | Publication Year | Journal | Type of Study | MINORS score |
|---|---|---|---|---|
| Barber et al | 1995 | J Oral Maxillofac Surg | pilot study | 8 |
| Barber et al | 1995 | Implant Dent | pilot study | 6 |
| Roumanas et al | 1997 | Plast Reconstr Surg | pilot study | 7 |
| Teoh et al | 2005 | Int J Oral Maxillofac Implants | retrospective chart review | 8 |
| Raoul et al | 2009 | J Craniofac Surg | retrospective chart review | 8 |
| Odin et al | 2010 | J Oral Implantol | case report | 8 |
| Salinas et al | 2010 | J Oral Maxillofac Surg | retrospective chart review | 10 |
| Bodard et al | 2011 | Rev Stomatol Chir Maxillofac | retrospective chart review | 8 |
| Pellegrino et al | 2018 | Clin Implant Den Relat Res | retrospective chart review | 7 |
| Barbier et al | 2019 | Int J Prosthodont | pilot study | 12 |
| Byun et al | 2020 | J Clin Med | case series | 10 |
| Sandoval et al | 2020 | Clin Implant Den Relat Res | retrospective chart review | 12 |
| Antúnez-Conde et al | 2021 | Front Oncol | retrospective chart review | 9 |
| Lodders et al | 2021 | J Craniomaxillofac Surg | retrospective chart review | 10 |

Articles were published between 1995-2021, most within oral and maxillofacial surgery literature. 8/14 were retrospective chart reviews, 4 were pilot studies detailing protocols for implantation and 2 were a case series and case report.

## DISCUSSION

### TIMING OF PLACEMENT

Timing was addressed in 13 out of 14 studies. Immediate implantation was associated with a **statistically significant increased survival.** Dental implants were traditionally not placed at time of reconstruction due to concerns for free flap compromise, poor healing, delayed adjuvant treatment with subsequent complications or alterations in homogeneity of RT due to scatter or formation of “hot spots”. Alternatively, some authors advocate for immediate placement, citing decreased risks of failure of osseointegration, fractures, or subsequent ORN.

### RADIATION THERAPY

Five articles compared RT to no RT with 3 reporting statistically significantly worse outcomes with RT. Unfortunately, none of the articles provided enough raw data to run pooled analyses, thus we cannot comment on whether the findings would remain significant. There was also a paucity in reporting the type of radiation treatment used, be it IMRT, VMAT, SBRT, etc. Additionally, most studied did not comment on survival in terms of timing of RT.

### HYPERBARIC OXYGEN

This treatment pre- and post-implantation remains controversial. In all studies, patients followed Marx protocol. There was no statistically significant difference with hyperbaric oxygen.

### COMPLICATIONS

**19% of patients**

Finally, 10/14 studies reported complications with an overall 19% complication rate other than implant failure, such as ORN, pathologic fractures, plate exposure, osteomyelitis and other infections (18/96 patients).

## CONCLUSIONS

Immediate placement of dental implants appears to improve survival. RT may negatively impact survival based on multiple studies; however pooled analysis was unable to be completed. Lastly, the data on hyperbaric oxygen remains controversial. Overall, rates of complications in patients with implants who receive radiation are not insignificant, and data on timing of radiation therapy warrants further study.

We hope this paper serves as a catalyst for larger, multi-institutional or prospective studies on this topic for enhancement of implant protocol.

## REFERENCES

Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg. 2003;73(9):712-716. doi:10.1046/j.1445-2197.2003.02748.x
Salinas TJ, Desa VP, Katsnelson A, Misiro M. Clinical evaluation of implants in radiated fibula flaps. J Oral Maxillofac Surg. 2010;68(3):524-529. doi:10.1016/j.joms.2009.09.104
Byun SH, Lim HK, Yang BE, Kim SM, Lee JH. Delayed Reconstruction of Palatomaxillary Defect Using Fibula Free Flap [published correction appears in J Clin Med. 2020 Jun 02;9(6):]. J Clin Med. 2020;9(3):884. Published 2020 Mar 24. doi:10.3390/jcm9030884
Bodard AG, Bérner J, Goumrhi R, et al. Dental implants and free fibula flap: 23 patients. Rev Stomatol Chir Maxillofac. 2011;112(2):e1-e4. doi:10.1016/j.stomax.2011.01.008
Barber HD, Seckinger RJ, Hayden RE, Weinstein GS. Evaluation of osseointegration of endosseous implants in radiated, vascularized fibula flaps to the mandible: a pilot study. J Oral Maxillofac Surg. 1995;53(6):640-645. doi:10.1016/0278-2391(95)90158-2
Barbier L, Pottel L, De Ceulaer J, et al. Evaluation of Quality of Life After Mandibular Reconstruction Using a Novel Fixed Implant-Supported Dental Prosthesis Concept: A Pilot Study. Int J Prosthodont. 2019;32(2):162-173. doi:10.11607/ijp.6001
Sandoval MJ, Rosen EB, Robert AJ, Nelson JA, Matros E, Gelbum DY. Immediate dental implants in fibula free flaps to reconstruct the mandible: A pilot study of the short-term effects on radiotherapy for patients with head and neck cancer. Clin Implant Dent Relat Res. 2020;22(1):91-99. doi:10.1111/cid.12870
Odin G, Balaguer T, Savoldelli C, Scarbeck G. Immediate functional loading of an implant-supported fixed prosthesis at the time of ablative surgery and mandibular reconstruction for squamous cell carcinoma. J Oral Implantol. 2010;36(3):225-230. doi:10.1563/AAID-JOI-D-09-00031
Teoh KH, Huryn JM, Patel S, et al. Implant prosthodontic rehabilitation of fibula free flap reconstructed mandibles: a Memorial Sloan-Kettering Cancer Center review of prognostic factors and implant outcomes. Int J Oral Maxillofac Implants. 2005;20(5):738-746.
Lodders JN, Leusink FKJ, Ridwan-Pramana A, et al. Long-term outcomes of implant-based dental rehabilitation in head and neck cancer patients after reconstruction with the free vascularised fibula flap. J Craniomaxillofac Surg. 2021;49(9):845-854. doi:10.1016/j.jcms.2021.03.002
Pellegrino G, Tarsitano A, Ferri A, Corinaldesi G, Bianchi A, Marchetti C. Long-term results of osseointegrated implant-based dental rehabilitation in oncology patients reconstructed with a fibula free flap. Clin Implant Dent Relat Res. 2018;20(5):852-859. doi:10.1111/cid.12658
Antúnez-Conde R, Salmerón JI, Díaz-Monserrat A, et al. Mandibular Reconstruction With Fibula Flap and Dental Implants Through Virtual Surgical Planning and Three Different Techniques: Double-Barrel Flap, Implant Dynamic Navigation and CAD/CAM Mesh With Iliac Crest Graft. Front Oncol. 2021;11:719712. Published 2021 Oct 5. doi:10.3389/fonc.2021.719712
Raoul G, Ruivo B, Brix S, et al. Microsurgical reconstruction of the jaw with fibular grafts and implants. J Craniofac Surg. 2009;20(6):2105-2117. doi:10.1097/SCS.0b013e3181bee511
Roumanas ED, Markowitz BL, Lorant JA, Calcaterra TC, Jones NF, Brunner J 3rd. Reconstructed mandibular defects: fibula free flaps and osseointegrated implants. Plast Reconstr Surg. 1997;99(2):356-365. doi:10.1097/00006534-199702000-00008
Barber HD, Seckinger RJ, Hayden RE. Reconstruction of the head and neck cancer patient with a vascularized fibula flap and dental implants: preliminary clinical report. Implant Dent. 1995;4(2):111-114. doi:10.1097/00008505-199505000-00006
Panchal H, Shamsunder MG, Petrovic I, et al. Dental Implant Survival in Vascularized Bone Flaps: A Systematic Review and Meta-Analysis. Plast Reconstr Surg. 2020;146(2):637-648. doi:10.1097/PRS.0000000000007077
Jacobsen C, Kruse A, Lübbers HT, et al. Is mandibular reconstruction using vascularized fibula flaps and dental implants a reasonable treatment?. Clin Implant Dent Relat Res. 2014;16(3):419-428. doi:10.1111/cid.12004
Ch'ng S, Skoracki RJ, Selber JC, et al. Osseointegrated implant-based dental rehabilitation in head and neck reconstruction patients. Head Neck. 2016;38 Suppl 1:E321-E327. doi:10.1002/hed.23993
Feng W, Liu YF, Mo LJ, Xu JG, Zhang Y. Long-term results of mandibular reconstruction of continuity defects with fibula free flap and implant-borne dental rehabilitation. Int J Oral Maxillofac Implants. 2015;30(1):169-178. doi:10.11607/jomi.3691
Hakim SG, Kimmerle H, Trenkle T, Sieg P, Jacobsen HC. Masticatory rehabilitation following upper and lower jaw reconstruction using vascularised free fibula flap and enossal implants-10 years of experience with a comprehensive concept. Clin Oral Investig. 2015;19(2):525-534. doi:10.1007/s00784-014-1247-9
Awad ME, Altman A, Elrefai R, Snipman P, Looney S, Elsalanty M. The use of vascularized fibula flap in mandibular reconstruction: A comprehensive systematic review and meta-analysis of the observational studies. J Craniomaxillofac Surg. 2019;47(4):629-641. doi:10.1016/j.jcms.2019.01.027
Chiapasco M, Biglioli F, Autelitano L, Romeo E, Brusati R. Clinical outcome of dental implants placed in fibula-free flaps used for the reconstruction of maxillo-mandibular defects following ablation for tumors or osteoradionecrosis. Clin Oral Implants Res. 2006;17(2):220-228. doi:10.1111/j.1600-0501.2005.01212.x
Chronopoulos A, Zarra T, Ehrenfest M, Otto S. Osteoradionecrosis of the jaws: definition, epidemiology, staging and clinical and radiological findings. A concise review. Int Dent J. 2018;68(1):22-30. doi:10.1111/idj.12318
Shugaa-Addin B, Al-Shamiri HM, Al-Maweri S, Tarakji B. The effect of radiotherapy on survival of dental implants in head and neck cancer patients. J Clin Exp Dent. 2016;8(2):e194-e200. Published 2016 Apr 1. doi:10.4317/jced.52346
Zlotolow IM, Huryn JM, Piro JD, Lynchewski E, Hidalgo DA. Osseointegrated implants and functional prosthetic rehabilitation in microvascular fibula free flap reconstructed mandibles. Am J Surg. 1992;164(6):677-681. doi:10.1016/0002-9610(92)90733-0
Ueda M, Kaneda T, Takahashi H. Effect of hyperbaric oxygen therapy on osseointegration of titanium implants in irradiated bone: a preliminary report. Int J Oral Maxillofac Implants. 1993;8(1):41-44.
Marx RE, Johnson RP, Kline SN. Prevention of osteoradionecrosis: a randomized prospective clinical trial of hyperbaric oxygen versus penicillin. J Am Dent Assoc. 1985;111(1):49-54. doi:10.14219/jada.archive.1985.0074