

Review Article

Dental implants in irradiated jaws: A literature review

ABSTRACT

Surgical treatment of head and neck cancer frequently results in defects that challenge conventional prosthetic rehabilitation. Successful rehabilitation using tissue supported dentures in such cases has been reported to be less than 20%. With the loss of jaw bones and thus the support, there is loss of retention to a great deal. Also, teeth loss on the side of the defect adds to failure in retention. Scar tissue formation, deviation of jaw due to muscle pull, decreased mouth opening, loss of sulcus and non vertical force are some of the common adversaries of jaw resection especially mandibular resection which pose great limitation on the stability and success of prospective prosthetic rehabilitation.

The advent and application of biologically acceptable implants in clinical dentistry has contributed to restoring the defects of the deficient maxillofacial systems. Surgical intervention in patients who had received head and neck irradiation is preferably avoided as it has been associated with decreased healing and increased potential for development of osteoradionecrosis. Hence an implant as an option when surgical field has received tumerocidal radiation is empirically excluded.

The purpose of this article is to review the studies and reports published in various journals related to osseointegrated implant rehabilitation in irradiated bones.

KEY WORDS: Dental implants, osseointegration, radiation

INTRODUCTION

Rehabilitation following resection and reconstruction in head and neck cancer patients is a challenging goal to achieve. Adversaries of jaw resection limit the success of prospective rehabilitation. Today the defect of the deficient maxillofacial system can be restored with prosthesis anchored on to dental implants.

The search for cure of head and neck malignancies by surgery or medicine has its own disadvantage. Radiotherapy in head and neck regions lead to radiation caries. The replacement by conventional means of fixed prosthodontics is contraindicated in high caries risk individuals because of risk of abutment failure.^[1] Atrophied and erythematous mucosa and or resected jaw bones inhibits the placement of removable prosthesis. Thus the overall morbidity due to cancer therapy is added with failure to replace and restore satisfactory mastication leads to decreased quality of life.

The implantation of tooth / biomaterials has emerged as a promising field in restorative dentistry. This article focuses on the efficiency of

dental implants in irradiated bones.

HISTORY

An endosteal implant (implants embedded into bone) is an alloplastic material surgically inserted into a residual bony ridge primarily as a prosthodontic foundation^[2] and is the most preferred implant compared to its counterparts like transosteal and periosteal implants.

The history of root form endosteal implants dates back thousands of years. The Chinese carved and implanted bamboo sticks in jaw bones 4000 years ago. Egyptians used precious metals 2000 years ago and Maggiolo used gold in 1809. The Mayan civilization has been shown to have used the earliest known examples of endosseous implants, dating back to over 1,350 years.^[3]


In 1952, the Swedish orthopedic surgeon, Brånemark, while studying bone healing and regeneration, on animal and human subjects confirmed a unique property of titanium. Brånemark termed it as 'osseointegration'.^[4] Dr. Linkow known as the father of modern implant dentistry placed

Kanchan P. Dholam, Sandeep V. Gurav

Department of Dental and Prosthetics Surgery, Tata Memorial Hospital, Mumbai, India

For correspondence: Dr. Kanchan P. Dholam, Department of Dental and Prosthetic Surgery, Tata Memorial Hospital, Mumbai, India. E-mail: kdholam@hotmail.com



Access this article online
Website: www.cancerjournal.net
DOI: 10.4103/0973-1482.92220
Quick Response Code:


19000 dental implants from 1952 to 2002.^[3]

HEALING AROUND DENTAL IMPLANT

An adequate osseointegration is dependent on implant acceptance by living tissues as well as functional bone formation in the so-called bone–dental implant interface. The healing of this interface depends on biological and systemic patient-related issues,^[5-7] implant design,^[8,9] load distribution between bone and implant^[9,10] and the surgical procedure.^[11,12]

The healing of the injured tissues after the insertion of a dental implant begins with the formation of a fibrin clot that detains the blood flow and gives initial support to the osteoprogenitor cells. The adequate formation of this clot determines the direct and stable connection between bone and implant, i.e. osseointegration.^[13]

With the osseointegration ends a series of biological processes of tissue repair started with the injury caused during the surgical procedure of implant placement.

Bio physical and biochemical analyses of long-term experimental and clinical observation indicate that there is an active interchange between the implanted titanium fixture and soft and hard tissues, which eventually results in improved anchorage.^[12]

ALTERED BONE PHYSIOLOGY IN IRRADIATED PATIENTS

The reaction of bone after irradiation is either circulatory or metabolic.^[14] Initially, the circulatory hyperemic effect dominates; later, the metabolic changes become more significant. The metabolism increases in spite of decreased blood flow, secondary to vascular damage, due to the reactive cell surface in remodeling. This concept is supported by an early enzymatic increase after irradiation.^[15] Thus an interaction of cellular, vascular, and metabolic alterations occurs in the different components of bone and in the adjacent tissues.

The intensity of the reactions is highly variable and may be partly dose related, although it is also influenced by many other parameters related to radiation delivery. This often is a reversible process which has the potential to turn into severe and irreversible alterations such as bone necrosis.

All of the components of the irradiated bone have different degrees of sensitivity to radiation. Mineral bone is not considered to be radiosensitive. Non-mineralized elements such as the cartilage plate in growing bones, marrow cells, and osteogenic cells, are radiosensitive.^[16] The initial changes in bone result from depletion of the osteocyte population. Osteoblasts tend to be more radiosensitive than osteoclasts, so that after a course of radiotherapy there may be a disproportionately larger lytic activity. With excessive depletion

of the osteocyte population regions of the bone become devitalized and degenerative changes begin to develop. These changes are potentiated because the same doses of radiation will injure the small blood vessels of the bone as well as the oral mucosa.^[17] Radiation results in a decrease in qualitative osteoblast activity with reduced alkaline phosphatase activity.^[18] The periosteum is also affected by this loss of cellularity, vascularity, and osteoid formation.^[19]

Tolerance is greater for fractionated dose irradiation, than for single exposures to the same levels.^[16]

Jacobson *et al*,^[20] in a study on rabbits quantifies the bone regenerative capacity directly after administration of 15 Gy ⁶⁰Co irradiation. It was found that bone regeneration was depressed by 70.9% within a four-week period after irradiation. At a follow-up of one year, the average depression of bone-forming capacity was only 28.9%. This means a recovery by a factor of almost 2.5 in 12 months. Hence he advocates reconstruction and insertion of dental implants will be more successful with longer time span between irradiation and surgery.

Irradiation leads to the formation of hypoxic-hypocellular and hypovascular tissue, and then to the breakdown of tissue driven by persistent hypoxia which can cause a chronic nonhealing wound.^[21] This damage can cause cell death. Functional loss of salivary gland tissues if in the radiated volume along with the presence of carious teeth or any oral or systemic bacterial infection enormously increases the risk of mandibular osteoradionecrosis (ORN).^[21]

ANIMAL STUDIES

Laboratory^[22] and clinical^[23-25] studies of titanium implants in irradiated bone have been conducted in rabbits. The bone formation on hydroxyapatite (HA) implant surface has been observed to occur earlier than on titanium implants.^[26] HA is also a more biocompatible material than titanium.^[27]

This finding is also supported by the histologic and histomorphometric analysis of bone remodeling in rabbits. More trabecular bone was present around the HA implant in controls than in the irradiated groups. If more trabecular bone is present around the implant, more force can be absorbed by the cancellous bone area. Therefore, HA implants in irradiated bone should be placed so that bearing by the cortical bone area is increased, for example, bicortically.^[28] However according to Schon *et al*,^[29] in the rabbit, osseointegration of an HA implant was found to be less efficient than that of a titanium implant.

The histologic effects of postimplantation irradiation on hydroxyapatite (HA)-bone contact have been investigated in several experimental studies. Schon *et al*^[29] evaluated the tissue reaction around HA implants placed in the mandible of the rabbit five days before irradiation with a single 15-Gy ⁶⁰Co dose. In their study, two of the eight HA implants failed to contact

the bone directly. Weinlander *et al.*^[30] concluded that post implantation radiation had a deleterious effect on implant-bone contact. In his study, radiotherapy consisted of a dose equivalent to 5,000 cGy delivered in four fractions over a two-week period, and was started three weeks postimplantation. Khateery *et al.*^[31] investigated the influence of radiotherapy (2,250 cGy in three doses over five days) on subperiosteal HA coated implants in rabbits. In contrast to the findings of Schön *et al.*^[29] and Weinlander *et al.*^[30] they observed that the amount of bone formation around the implant was significantly greater in the irradiated sites.

To clear these differences Kudo *et al.*^[32] histologically and histomorphometrically studied the effect of radiation in rabbits irradiated at three different time points after placement of implants. He concluded that therapeutic irradiation shortly after implantation inhibits direct contact between the HA implant and the surrounding bone. Regardless of the interval between implantation and irradiation, postimplantation irradiation inevitably delays bone remodeling.

According to Asikainen *et al.*^[33] bone remodeling can occur only when irradiation is fractionated, because this leads to higher tissue tolerance .

The therapeutic timing and length of delay between irradiation and implantation appear decisive to ensure the correct osteogenic reaction and thus osseointegration. This delay adapted from the present animal model corresponds to a six-month period after radiotherapy.^[34] A similar observation was found in the histological analysis of the mandibular bone of dogs 24 weeks after implantation. There was a higher level of remodeling in the irradiated animals than in the non-irradiated ones.^[35]

Shirota *et al.*^[36] in their study on rats observed that aging is an important factor in prognosis of the HA implant in irradiated bone.

A tumoricidal dose of 4,500 rads in ten fractions delivered to the mandibles of rhesus monkeys produced clinically observable changes similar to those seen in human patients (namely mucositis, inability to eat, xerostomia). Microscopically, changes included loss of osteocytes from bone lacunae in Haversian bone but not in cancellous bone, changes in the cellularity and vascularity of the periosteum, fibrosis with loss of principal fiber arrangements and decrease of vessels in interstitial spaces. Marrow showed fibrosis with obliterative endarteritis, loss of hematopoiesis and proliferation of new bone. Narrowing or obliteration of blood vessels and plugging of some canals with osteoid were changes observed in the Haversian canals.^[37]

HUMAN STUDIES

Placement of implants pre or post radiotherapy:

The results of Schepers *et al.*'s^[38] study show that implants,

primarily inserted during ablative surgery and exposed to a range of radiation doses, have an equal chance of becoming functional when compared to implants that received no radiation. The success rate of osseointegration was 97% in the postoperative irradiated group and 100% in the non-irradiated group. Rehabilitation can start early and problems related to postoperative radiotherapy may be prevented. A large part of the integration will occur in the period between surgery and radiotherapy, i.e. within four to six weeks.^[39] In a healthy mandible, the whole integration process will take close to three months. Primary implant placement may have the following advantages over secondary implant placement. (a) Implant-surgery in a, due to radiotherapy, compromised area is avoided thus reducing the risk of late complications, i.e. osteoradionecrosis, (b) early rehabilitation of speech and swallowing, and (c) another surgical intervention and need for adjunctive HBO therapy can be avoided.

Schoen^[40] too recommends insertion of implants immediately following the ablative procedure during the same surgical session when postoperative radiotherapy is indicated. A major disadvantage of immediate implant insertion concerns the risk of improper implant positioning. This impairs the prosthodontic treatment and can sometimes even not be used in the prosthodontic rehabilitation of a patient.^[41] Other disadvantages include the risk of interference with or delay of the oncological therapy including radiation therapy, and the development of post-treatment complications caused by implantation being performed during ablative surgery.^[41] These disadvantages are assessed to be of minor importance because of the very low incidence and morbidity, especially when compared to the high risk of harmful tissue reactions in the case of implantation after radiotherapy.^[42] A two-stage technique is advocated to minimize the risk of early post-ablative complications as the implants are covered by mucosa during radiation therapy. Finally, by using multiple radiation fields, backscatter doses can be minimized and are of negligible clinical relevance.^[43]

It is shown that implants placed after finishing postoperative radiotherapy, osseointegrate well depending on the total dose of radiotherapy.^[44-51] Up to 35% of the implants secondarily placed in irradiated mandibular bone are reported to be lost because of problems in osseointegration.^[52]

Nelson^[53] used different implant systems with different surface topographies (acid-etching and airborne-particle abrasion) and found these to have an equivalent osseointegration potential.

Werkmeister *et al.*^[51] advocate the abandonment of non vascularized bone graft whenever implant placement is planned in irradiated areas.

Eckert *et al.*^[54] studied the success of endosseous implants in irradiated tissue bed. The results demonstrate a higher implant survival rate in the mandible as compared to maxillae.

In a pilot study on quality of life assessment in implant retained prosthetically reconstructed maxillae and mandibles, Dholam *et al.*,^[55] attributed radiation of the tissues as the primary cause of failures in implants at stage I and II of implant surgery. They also found peri-implantitis and proliferative growth around implants in skin grafted mucosa.

Radiation dose

Colella *et al.*,^[56] in a review on implants in radiated bones found that no failures were observed in association with an radiation dose lower than 45 Gy. All implant failures observed occurred within 36 months after radiation, and most occurred between one and twelve months after placement.

Location and site of implants in jaws

Roumanas *et al.*,^[57] demonstrated by location an implant success rate of 80% in the anterior maxilla and 66% in the posterior maxilla in radiated patient.

Nishimura^[47] observed that in clinical practice, most patients irradiated for head and neck tumors do not receive radiation to the symphyseal region. Therefore implants can be placed in this region with a high degree of predictability when it is out of the field of irradiation. The risks of osteoradionecrosis (ORN) should be considered when this region is in the treatment field. In the maxilla, the risk of bone necrosis is probably negligible due to its diffuse blood supply and larger treatment volume when irradiated. The implants placed into the irradiated anterior mandible have demonstrated an acceptable implant success rate of 94% to 100% with a minimal risk of osteoradionecrosis. The efficacy of implants in the posterior mandible has not been examined. Implant success rates ranged from 69% to 95% in the irradiated maxilla for intraoral applications.

Timing of implant placement

Jacobson *et al.*,^[58] recommended that dental implantation should be done at least after one year of completion of radiation. Taylor *et al.*,^[59] and Franzen *et al.*,^[60] believe that implant placement should be delayed at least two years after completion of irradiation therapy. The results of animal experiments in Gothenburg^[58] suggest that some revascularization of irradiated bone will occur longitudinally and that a delay of two or more years is beneficial. The additional time after tumor therapy also reduces the risk of tumor recurrence. Wagner *et al.*,^[61] feel that the time interval between irradiation and dental implantation should be 15 months and the time interval between implantation and reconstruction four months.

Timing of abutment placement and loading the implants

Taylor *et al.*,^[59] assume that bone healing and osseointegration occur at a slower rate than in normal tissue. For this reason abutment connection should be delayed for six months. Loading of the soft tissues in the area of the surgical site should be avoided completely during the healing phase.

Branemark *et al.*,^[4] advocated an unloaded healing time of three to six months. This is in contrast to the implant loading protocols, progressive loading^[62] and immediate loading.^[63] A healing period without loading is currently still considered as a prerequisite for implant integration. This leads to extended treatment periods often with delayed functional improvement for the patient.^[64-68] Early loading has been found to induce micromotions at the bone-implant interface that may lead to a fibrous encapsulation instead of direct bone apposition.^[66,67]

Type of prosthesis

Cuesta-Gil^[69] advocate placement of a single type of prosthesis—in most cases implant-retained overdentures. These prostheses facilitate occlusal fitting, require fewer implants, facilitate gingival hygiene, distribute the occlusal forces (thereby avoiding stress on the implants), and are less expensive. Fixed prostheses are less indicated in such patients because the treatment involved is more complex and costly and requires a larger number of implants (with perfect placement). Moreover, occlusal fitting is more difficult, hygiene, and the follow-up is poorer of implants and there is the possibility of oncologic disease relapse. Meijer *et al.*,^[70] recommended fixed dentures on only two implants in irradiated edentulous patients. Their philosophy is that, it minimizes the trauma of placing four implants in radiated patients and reduces the chewing force. Trismus and mucosal conditions make it difficult to achieve sufficient vertical dimension for four implant supported over denture.

Fixed partial dentures in the mandible appear to be a feasible alternative in fully edentulous head and neck cancer patients after ablative cancer surgery and irradiation therapy. With respect to implant survival, there is ample support for the hypothesis that fixed prostheses lead to higher success rates than removable ones.^[71]

Success and failure of implants

Success and failure rate of implants in irradiated bone by various authors is mentioned in Table 1.

USE OF HYPERBARIC OXYGEN

Hyperbaric oxygen (HBO) is defined as the breathing of oxygen under increased pressure in a pressure chamber (two to three atmospheres absolute). HBO inhibits leukocyte adhesion to endothelium, diminishing tissue damage, and enhances leukocyte motility, resulting in improved microcirculation.^[72] In the short term, this causes an increase in the tissue's internal oxygen pressure, leading to vasoconstriction, enhanced oxygen delivery, edema reduction, phagocytose activation, and an anti-inflammatory effect.^[73]

The long-term effects are neovascularization, osteogenesis, and a stimulation of collagen production by fibroblasts, which promote wound healing.

Table 1: Implant failure rate by various authors

Investigators	No. of patients /non irradiated patients / radiated patients	Total implants /in non irradiated patients/ in irradiated patients	Non irradiated implant failure	Failed without HBO [failed to osseointegrate]	Failure in HBO treated [if applicable]	Avg RT dose	Comment
Schepers <i>et al</i> ^[38] 2006	48 27	139 78	0%	3%	NA	60-68 Gy	Primary implant placement may have advantage over secondary
Schoen <i>et al</i> ^[40] 2008	21 19 31	61 64 76	3%	3%	NA	60 +/-7.7 Gy	Quality of life and denture satisfaction is improved in patients with implant supported prosthesis
Nelson <i>et al</i> ^[63] 2007	93	435 311 124	1.2%	5.64%	NA	<72Gy	The mean 10.3 years survival rate was low. Increased failure rate was caused by the higher mortality rate.
Cuesta-Gil <i>et al</i> ^[69]	111 32 79	706 311 395	0.6%	6.8%	NA	50-60 Gy	Failure particularly affected the group of irradiated patients and those subjected to lateral osseomyocutaneous trapezial pedicled flap reconstruction.
Werkmeister <i>et al</i> ^[51]	29 17 12	109 60 49	14.7%	26.7%	NA	42-64 Gy	Soft tissue complications found in 28.6 % irradiated patients and 8.3% non-irradiated result for first 36 months
Eckert <i>et al</i> ^[54]	20 0 20	124 0 124	NA	12 %	NA	2005-6602 cGy	Implant survival is 99% in mandibles, 64% in maxillae and 46% in extra oral sites
Taylor, Worthington ^[59]	4 0 4	21	NA	0%	0%	6000-6480cGy	Radiation dose 5580cGy to 6480 cGy 3 to 7 years follow up 3 out of 4 patients treated with HBO
Franzen <i>et al</i> ^[60]	5 0 5	20 0 20	NA	5%	NA	25-64 Gy	Adjunctive measures such as HBO or the avoidance of using vasoconstrictor in LA were not always necessary.
Arcuri <i>et al</i> ^[75] 1997	4 0 4	18 0 18	NA	NA	6%	5580-6480 cGy	All 4 patients treated with HBO 1-5 year follow up 5580 cGy to 6480 cGy
Schoen PJ <i>et al</i> ^[79]	26 13 HBO treated 13 non HBO treated	103	NA	6.1%	14.8%	46 Gy (mean 61.4 ± 12.9 Gy, range 46–116 Gy)	Implant-retained lower dentures can improve the quality of life related to oral functioning and denture satisfaction in head and neck cancer patients. Adjuvant hyperbaric oxygen therapy could not be shown to enhance implant survival in radiated mandibular jaw bone.
McGhee <i>et al</i> ^[83]	6 1 5	26 5 21	0%	9%	NA	>50Gy	Osseointegration occurred in 92% (24/26) of the implants:100% (14/14) in neomandibles and 83% (10/12) in native mandibles.
Keller <i>et al</i> ^[12]	19 0 19	98 0 98	NA	1.2 %	NA	60 (50–66) Gy	99% implant success rate. 72 implants in residual irradiated bone, 26 in bone grafted in irradiated tissue.
Visch <i>et al</i> ^[49]	130 0 130	446 0 446	NA	14%	NA		Implant survival is significantly influenced by the location (maxilla or mandible, 59% and 85%, respectively), by the incidence of bone-resection surgery in the jaw where the implant was installed , and by the irradiation dose at the implant site (< 50 Gray or > 50 Gray)

The European Committee for Hyperbaric Medicine categorized the use of HBO in ORN of mandible as “strongly recommended” and surgery and implant in irradiated tissue as “recommended”.^[72]

Marx,^[21] the founder of the so-called 3H model (hypoxia,

hypocellularity, hypovascularity) of the pathogenesis of ORN, has introduced ‘Marx protocol’ for HBO and implants. He suggests 20 “dives” before treatment and 10 “dives” after treatment of osseointegrated implants. Larsen^[74] too supports this regimen.

Arcuri^[75] states that the success of osseointegration with HBO was 94% in his study.

In contrast, Keller^[76] does not advocate the use of adjuvant HBO therapy in view of economic factors, potential complications of HBO therapy, and the low incidence of complications without its use.

Granstrom *et al.*^[77] recommends adjuvant HBO for reducing the failure rate of implants in irradiated bone.

Barber *et al.*^[78] concluded that factors such as the graft having its own blood supply and the use of HBO contributed to the successful osseointegration of these implants.

There is only one randomized controlled trial conducted by Schoen *et al.*^[79] reported in the Cochrane review.^[80] The outcome of this trial showed that there was no clinical significant difference between HBO treated and non-HBO treated patients with regard to implant success. The better performance was shown by patients not treated with HBO on almost every aspect of this controlled trial. A possible explanation was the extra treatment burden encompassing thirty sessions of HBO, affecting quality of life. The study population of this trial was small, and a very large population is needed to detect the usefulness of HBO therapy. It is doubtful, however, whether such a large randomized controlled trial will actually prove effective, and the clinical use of HBO is remarkable considering the existing opposing views on its efficacy and value.

Experimental research in the last two decade regarding the effect of HBO therapy on previously irradiated head and neck tissue is scarce. It is therefore concluded that more research, both clinical and experimental, is necessary before conclusions can be drawn.

DISCUSSION

Implant material: Most of the studies are on titanium implants.^[38,40,42-51] The hydroxyapatite coated implants are also found to be successful mainly because of its rough surface and the osseoconductive properties of hydroxyapatite.^[29] Advanced dental implant surfaces like TPS [titanium plasma sprayed], SLA [sandblasted and acid etched], Ti-Unite and different implant materials like zirconia [zirconium oxide] have showed comparable results in non irradiated bones but long-term evaluation and studies are required to judge their survival rate in irradiated bones.

Implant position: With regard to the anatomical position, implants can be best placed in the mandibular anterior / symphyseal region [success rate of 94% to 100%] as it is the area which receives the least amount of radiation.^[47] The ability of the anterior mandible to maintain viable bone, even when the posterior regions are highly radiated was demonstrated by Gowgiel.^[81] It is also found to be the safest area of the

mandible as far as osseointegration is concerned followed by the mandibular premolar region and the maxillary jaw. The maximum implant failures are reported in the maxillary jaw [69% to 95%]^[47] which is least prone to ORN because of its diffuse blood supply and cancellous bone.

Werkmeister *et al.*^[51] advocate the abandonment of non vascularized bone graft whenever implant placement is planned in irradiated areas. Hence insertion of implants in vascularized bone grafts is advocated.

Type of prosthesis: Fixed implant supported prosthesis is advocated in irradiated mandibles. The implant supported over dentures is better in vascularized or non-vascularized grafted patients. Fixed over denture type of prosthesis is advised by Meijer *et al.*^[70] supported by two implants.

Effect of radiation dose: The radiation dose has an effect on osseointegration. Favorable osseointegration is found in radiation doses lesser than 45-50 Gy.^[56]

Type of irradiation source: Most studies published on osseointegration in irradiated tissues have used ⁶⁰Co as the source for radiotherapy. With the development of higher energy radiotherapy protocols and superfractionation, it is likely that in time other effects on osseointegration will be identified. Brachytherapy is also a part of oncologic treatment, and its effect on bone tissues is different from external beam radiotherapy. Again, too little is known about its effect on osseointegration today.

Effect of smoking: Smoking has negative effects on osseointegration.^[82] The vasoconstriction and vascular damage which causes decreased vascular supply lead to implant failure. A smoking cessation protocol^[82] before implant placement is accepted globally. Hence radiated patients who continued to smoke must be considered as an absolute contraindication to treatment.

Soft tissue complications: Soft tissues around implants behave differently in radiated bones than in non radiated bones. Eckert *et al.*^[54] noted that significant problems in patients with irradiated implants were related to the soft tissues. Gingivitis was more common in these patients than normally observed. Cover-screw mucosal perforations were observed over the areas of 17% of implants during the healing period between stage one and stage two surgery.

August *et al.*^[44] reported increased problems with the soft tissues. Early soft tissue complications included soft tissue overgrowth, tongue ulceration, and intraoral wound dehiscence. Late complications included fistula formation.

Dholam^[55] also found soft tissue complications especially irradiated osteomyocutaneous grafted patients.

Primary vs secondary implant placement

More predictable osseointegration has been reported with primary placement of implants before radiotherapy.^[38,39] The cost factor, improper positioning of implants, and the late effects of treatment (surgery, radiation) like fibrosis inducing trismus, favor secondary placement. The patient too, by this time, is aware of the altered physical and physiological state and accepts the shortcomings and is psychologically prepared to extend the treatment and get rehabilitated.

Hyperbaric oxygen

The use of HBO is still controversial. Some studies found it useful^[74,75,77] while others considered it as an additional burden of treatment.^[76,79] The studies failed to prove cost effectiveness of HBO as a supportive care in implant osseointegration.

Timing of implant placement

One year time interval between tumor therapy and the time of dental implantation as recommended by Jacobson^[58] seems logical. This period facilitates the tissues to recover from the immediate side effects of radiation and the bone remodeling and vascularization to set in. The patient is rehabilitated in a reasonable time period too.

Timing of abutment placement and loading the implants

Abutment connection, fabrication and loading of the prosthesis should be delayed for six months instead of the traditional three to four months to permit osseointegration.^[64-68] This extra time period assists in achieving uninterrupted and unloaded osseointegration.

CONCLUSIONS

Factors which contribute to the success of implant retained oral rehabilitation in radiated patient are careful selection of patients after evaluating the clinical conditions and results following surgery, reconstruction, radiation, prognosis and the cost factor. Insertion of implant should be undertaken after one year of radiation and attachment of abutment and prosthesis fabrication after six months of insertion of implant. This period is necessary to achieve osseointegration after receiving radiation. Placement of a minimum number of implants is advocated. Prosthesis can be fabricated on two implants. Fabrication of over denture in radiated jaw and fixed denture in microvascular grafted jaw is advocated. Insertion of implants should be preferably done in microvascular grafted jaws.

Hydroxyapatite-coated titanium implants is the material of choice today. Increased failure rates are observed when the radiation dose exceeds 45Gy. The implant success rate is higher in the mandibular symphyseal region followed by the mandibular posterior region and least maxilla. To assess the effects of HBO treatment on acceleration of osseointegration, more randomized trials are required.

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Cite this article as: Dholam KP, Gurav SV. Dental implants in irradiated jaws: A literature review. *J Can Res Ther* 2012;8:85-93

Source of Support: Nil, **Conflict of Interest:** None declared.

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