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Dental Implant Success in the Setting of Irradiated Head and Neck Cancer Patients: A Scoping Review.

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ABSTRACT: Oral cancer, particularly oral squamous cell carcinoma, remains a major global health issue, with a notable impact on older males and those with a history of tobacco and alcohol use. Despite advancements in treatment, including surgery and radiotherapy, survivors face significant challenges in oral function. Dental implants have emerged as a promising solution for restoring function and aesthetics post-cancer treatment, but their success in irradiated head and neck cancer patients is complicated by impaired bone healing and a higher risk of osteoradionecrosis (ORN).

Studies indicate lower implant survival rates in irradiated patients (91.9%) compared to non-irradiated patients (97%). Although ORN occurs in 1.6% to 3% of cases, it poses serious risks. Adjunctive therapies like hyperbaric oxygen therapy, bone grafting, low-level laser therapy, bone morphogenetic proteins, and platelet-rich plasma are being explored to enhance outcomes. A multidisciplinary approach, including careful planning and patient education, is essential for optimizing implant success and improving quality of life for these patients.

KEYWORDS: Oral Cancer, Dental Implants, Radiotherapy, Osteoradionecrosis, Adjunctive Therapies.

I. INTRODUCTION

1.1 Background:

Oral cancer remains a significant global health concern, ranking as the sixth most common cancer worldwide, with oral and pharyngeal malignancies representing a considerable burden. These malignancies typically manifest in older populations, particularly in males over the age of 50, and are often associated with lifestyle factors such as tobacco and alcohol use. (1,2) Oral squamous cell carcinoma, the most prevalent type of oral cancer, is exacerbated by poor oral hygiene and delayed detection. Although survival rates have improved due to advances in surgery, chemotherapy, and radiation therapy, cancer treatment significantly impacts the patient's quality of life, particularly in oral function.

In recent decades, dental implants have emerged as a valuable treatment option to restore function and aesthetics in patients with diminished oral capabilities post-cancer treatment. However, in head and neck cancer patients who have undergone radiotherapy, the use of dental implants is not without challenges. These patients face complications such as altered anatomy, impaired healing, and the risk of osteoradionecrosis (ORN). Despite these concerns, dental implants offer a potential solution for restoring oral function, provided the risks are well-managed. (3)

Dental implants have revolutionized the rehabilitation of patients who have lost teeth due to cancer-related surgeries or radiotherapy. These implants improve mastication, speech, and aesthetics, significantly enhancing the patient's overall quality of life. (4) The literature reveals that while dental implants have been widely successful in healthy populations, their success in irradiated patients is less certain. (5)

II. DENTAL IMPLANT SURVIVAL IN IRRADIATED PATIENTS

2.1 Radiotherapy & its effect on bone healing:

Radiotherapy is a cornerstone of cancer treatment for head and neck malignancies. However, it can have devastating effects on bone healing, particularly in the mandible and maxilla. Radiation doses exceeding 50-60 Gray are known to impair bone regeneration, leading to a higher risk of implant failure and ORN. (5,6)

Radiation-induced damage to bone tissue is characterized by endarteritis, leading to reduced vascularity, hypoxia, and impaired healing. (7) These changes make it more difficult for the bone to integrate dental implants successfully. Studies have shown that waiting at least 12 months after radiation therapy before placing implants can improve outcomes, as this allows time for the bone to recover to some extent. (8)

Implant survival in irradiated head and neck cancer patients has been a key concern for clinicians. Studies have consistently shown that irradiated bone tissue exhibits impaired healing, which can impact the osseointegration of dental implants. (9) The survival rate of implants in these patients is lower compared to non-irradiated patients, primarily due to the compromised vascularity and bone quality resulting from radiation therapy. (8,9)

One study included in this review indicated a survival rate of 91.9% for implants placed in irradiated patients after a follow-up of approximately 40 months. This is significantly lower than the 97% survival rate observed in non-irradiated patients. (10, 11) However, despite the lower survival rate, dental implants remain a viable option for oral rehabilitation in irradiated patients, particularly when other options are limited.

2.2 Immediate vs delayed implant placement:

The timing of implant placement relative to radiation therapy has been the subject of much debate. Some studies suggest that placing implants more than 12 months after radiation therapy reduces the risk of failure, while others argue that delaying too long may also have negative consequences. (9, 12) The balance between waiting for bone recovery and minimizing the risk of tumour recurrence is a critical consideration for clinicians.

Immediate implant placement, where implants are placed during or shortly after cancer surgery, has been associated with a higher risk of failure in irradiated patients. (13) This is due to the compromised healing environment caused by radiation and the need for extensive reconstructive surgeries. Delayed placement, on the other hand, allows time for the bone and soft tissues to heal, potentially improving implant survival. (14)

A study in the literature found that delayed implant placement had a significantly higher success rate than immediate placement, with an odds ratio of 3.2 for implant failure in patients who received immediate implants. This finding underscores the importance of allowing time for tissue recovery before attempting implant placement in irradiated patients.

III. SETTING OF OSTEORADIONECROSIS

3.1 Literature findings:

Osteoradionecrosis (ORN) is one of the most serious complications associated with the placement of dental implants in irradiated patients. ORN is characterized by necrosis of the irradiated bone and is often precipitated by trauma, such as dental implant placement or tooth extraction. (14) The literature reveals that ORN can occur even years after radiation therapy, with some cases reported more than five years post-treatment. (15)

The incidence of ORN following dental implant placement in irradiated patients is relatively low, with studies reporting rates between 1.6% and 3%. (16) Despite this, ORN remains a concern for clinicians due to its unpredictable nature and potential for severe morbidity. Several factors have been identified as contributing to the risk of ORN, including the dose of radiation, the location of the implant, and the use of adjunctive therapies such as hyperbaric oxygen therapy (HBO). (17)

In literature, no significant correlation was found between radiation doses exceeding 60 Gray and the development of ORN. (6, 17) However, the use of HBO and bone grafting has been associated with an increased risk of ORN in some studies. (18) Given the rarity of ORN, it is challenging to establish clear risk factors, and further research is required to develop preventive strategies.

IV. FACTORS INFLUENCING IMPLANT SUCCESS IN IRRADIATED PATIENTS

4.1 Patient selection & risk stratification:

Careful patient selection is critical to the success of dental implants in irradiated head and neck cancer patients. Several factors must be considered when determining whether a patient is a good candidate for implants, including the extent of radiation exposure, the patient's overall health, and their ability to maintain good oral hygiene. (19)

In addition to radiation dose and bone grafting status, other factors that influence implant success include smoking, alcohol use, and the presence of systemic diseases such as diabetes. Smoking and alcohol use are well-established risk factors for implant failure and ORN, as they impair wound healing and reduce vascularity. (15) Patients with poor oral hygiene are also at higher risk for peri-implantitis, which can lead to implant failure. (19)

4.2 Fixture & prosthetic factors:

4.2.1 Implant surface modifications:

Advancements in implant surface technology are also being explored to improve osseointegration in irradiated patients. Modifications to the surface of dental implants, such as roughening or coating with bioactive materials, can enhance the integration of the implant with the surrounding bone tissue. For example, titanium implants with sandblasted, acid-etched surfaces have been shown to improve bone-to-implant contact and enhance stability. (20)

In irradiated patients, where bone quality is compromised, the use of implants with modified surfaces may increase the chances of successful osseointegration. (19) Additionally, coatings with antimicrobial agents or growth factors could further improve healing and reduce the risk of infection and implant failure. (20) Future research should focus on developing and testing these advanced implant surfaces in irradiated populations to determine their effectiveness in improving implant survival rates.

4.2.2. Design and placement of prostheses:

The design and placement of prostheses for irradiated patients require special consideration due to the altered anatomy and compromised soft tissues resulting from cancer treatment. In particular, fixed prostheses may provide better stability and comfort than removable options, as they do not exert pressure on the delicate soft tissues. (21) However, the choice of prosthesis should be based on the patient's individual needs, preferences, and the condition of their remaining bone and soft tissues.

The use of digital technologies, such as computer-aided design and computer-aided manufacturing (CAD/CAM), has revolutionized prosthodontic rehabilitation by allowing for more precise and individualized treatment planning. (22) CAD/CAM technology can be used to design custom prostheses that fit the patient's unique anatomy, improving both function and aesthetics. Additionally, computer-guided implant placement can help to ensure optimal positioning of implants, reducing the risk of complications and improving long-term outcomes. (23)

4.2.3 Loading protocol:

Another important consideration in prosthodontic rehabilitation is the timing of implant loading. In healthy patients, immediate loading protocols, where the prosthesis is placed on the implant shortly after surgery, have gained popularity due to their convenience and shorter treatment times. (13, 24) However, in irradiated patients, immediate loading may not be advisable due to the increased risk of implant failure and delayed healing.

Studies suggest that delayed loading protocols, where the prosthesis is placed several months after implant surgery, may be more appropriate for irradiated patients. (25) This allows for sufficient healing time and osseointegration before the implant is subjected to functional loads. Future research should continue to explore optimal loading protocols for irradiated patients, with a focus on balancing the need for timely rehabilitation with the risk of implant failure. (13)

4.3 Bone grafting:

Bone grafting is often necessary in head and neck cancer patients who have undergone extensive resection of the jawbone. However, the use of bone grafts in irradiated patients presents additional challenges. Non-vascularized bone grafts, in particular, have been associated with lower implant survival rates due to poor vascularity and higher resorption rates. (26)

Vascularized bone grafts, such as fibula or iliac crest grafts, offer a better option for these patients, as they provide their blood supply and are more likely to integrate with the surrounding tissue. Several studies have demonstrated improved outcomes with vascularized grafts compared to non-vascularized grafts in irradiated patients. (26, 27) However, the complexity and cost of these procedures may limit their availability in some settings.

4.4 Adjunctive therapies:

4.4.1: HBO therapy:

Given the challenges associated with implant placement in irradiated patients, several adjunctive therapies have been explored to improve outcomes. Hyperbaric oxygen therapy (HBO) is one such therapy that has been used to enhance tissue healing and reduce the risk of ORN. (17) HBO involves exposing patients to high concentrations of oxygen in a pressurized chamber, which increases oxygen delivery to irradiated tissues and promotes healing. (17)

HBO has been shown to improve implant survival rates in some studies, but the evidence remains mixed. While a systematic review by Shah et al. (2017) suggested that HBO reduces the risk of implant failure, a Cochrane review by Esposito et al. (2013) did not find sufficient evidence to support its routine use. (28) More recently, a randomized controlled trial by Shaw et al. (2019) found that HBO did not significantly improve implant survival or reduce the risk of ORN. (29)

Despite these conflicting findings, HBO remains a valuable option for high-risk patients, particularly those with compromised healing due to radiation. The decision to use HBO should be made on a case-by-case basis, considering the patient's overall health, radiation dose, and the extent of tissue damage.

4.4.2 Low-Level Laser Therapy (LLLT)

Low-level laser therapy (LLLT) is emerging as a potential technique for promoting tissue regeneration and enhancing osseointegration around dental implants. (27) LLLT is believed to stimulate cellular activity, enhance blood circulation, and increase the production of growth factors and collagen, which are essential for wound healing and bone regeneration. Several studies have shown that LLLT can accelerate healing and reduce inflammation, making it a promising tool for use in irradiated tissues where healing is delayed. (29)

In irradiated head and neck cancer patients, the application of LLLT could be particularly beneficial in improving soft tissue health around implants and preventing complications such as peri-implantitis. However, further clinical trials are needed to establish optimal protocols for the use of LLLT in this patient population and to determine its long-term effects on implant survival.

4.4.3 Bone Morphogenetic Proteins (BMPs):

Bone morphogenetic proteins (BMPs) are a group of growth factors known to play a critical role in bone formation and regeneration. In implant dentistry, BMP-2 is commonly used to promote bone growth around implants, especially in areas of poor bone quality, such as irradiated bone. (17, 29) Studies have demonstrated that BMP-2 can enhance osseointegration by stimulating the differentiation of osteoprogenitor cells into osteoblasts, which are responsible for new bone formation.

The use of BMP-2 in combination with dental implants in irradiated patients holds promise for improving implant stability and success. However, BMP-2 is expensive, and its use must be carefully controlled due to potential complications, such as excessive bone growth or heterotopic ossification. As such, further research is required to optimize the dosage and delivery methods of BMP-2 in dental implantology.

4.4.4 Platelet-Rich Plasma (PRP):

Platelet-rich plasma (PRP) therapy involves concentrating a patient's platelets and growth factors and applying them to surgical sites to promote healing and regeneration. PRP has been shown to accelerate bone formation and soft tissue healing, making it a potentially valuable adjunctive therapy in implant placement for irradiated patients. (28)

While the use of PRP in healthy patients undergoing implant surgery has shown promising results, its application in irradiated patients requires further investigation. (29) Research should focus on determining the efficacy of PRP in enhancing osseointegration and preventing complications such as ORN and peri-implantitis in irradiated tissues. If proven effective, PRP could offer a simple and cost-effective way to improve implant outcomes in high-risk patients. (28)

4.4.5 Stem Cell Therapy:

Stem cell therapy is another area of interest in the field of dental implantology. Mesenchymal stem cells (MSCs) have the ability to differentiate into various cell types, including osteoblasts, which are essential for bone formation. (13, 29) The use of stem cells in combination with scaffolds and growth factors could enhance bone regeneration in irradiated tissues, providing a more favourable environment for dental implants.

Preliminary studies have shown that stem cell therapy can promote bone regeneration in patients with compromised bone quality, including those who have undergone radiation therapy. (29) However, the use of stem cells in clinical practice is still in its early stages, and further research is needed to establish standardized protocols, assess long-term outcomes, and ensure the safety and efficacy of this approach.

4.5 Patient education & follow-up:

Educating patients about the risks and benefits of dental implants is another important aspect of the multidisciplinary approach to care. Patients should be informed about the potential complications associated with implant placement in irradiated tissues, including the risk of ORN and implant failure. (12) They should also be advised on the importance of maintaining good oral hygiene and attending regular follow-up appointments to monitor the health of their implants and surrounding tissues.

Regular follow-up appointments are critical for detecting and addressing complications early, before they become more serious. This is especially important in irradiated patients, who are at higher risk for peri-implantitis, ORN, and other complications. (17) By closely monitoring these patients and providing timely interventions, healthcare providers can improve long-term implant survival and patient satisfaction.

4.6 Multidisciplinary approach:

The ultimate goal of dental implants in head and neck cancer patients is to restore function and improve quality of life. Successful prosthodontic rehabilitation allows patients to eat, speak, and smile with confidence, significantly enhancing their social and psychological well-being. (15) However, the complexity of implant placement in irradiated patients means that careful planning and coordination between surgeons, oncologists, and prosthodontists are essential.

Oncologists can provide valuable information about the patient's radiation exposure, tumour prognosis, and overall health, which can guide decisions about implant placement and timing. Prosthodontists, in turn, can work with surgeons to design prostheses that meet the patient's functional and aesthetic needs while minimizing the risk of complications.

Prosthodontists should be involved early in the treatment planning process, ideally before radiation therapy begins. This allows for the identification of potential implant sites that can be spared from high doses of radiation during treatment. By planning for future dental rehabilitation early in the cancer treatment process, the risk of implant failure and ORN can be reduced.

V. CONCLUSION

The placement of dental implants in irradiated head and neck cancer patients presents significant challenges due to the compromised bone quality and increased risk of complications such as osteoradionecrosis. However, with careful patient selection, the use of adjunctive therapies, and a multidisciplinary approach to care, dental implants can provide a viable solution for restoring oral function and improving quality of life in these patients.
Future research should focus on developing and refining techniques to enhance osseointegration and soft tissue healing in irradiated patients. Emerging therapies such as low-level laser therapy, bone morphogenetic proteins, platelet-rich plasma, and stem cell therapy hold promise for improving outcomes in this high-risk population. Additionally, advancements in implant surface technology and digital prosthodontic planning can further improve implant survival and patient satisfaction.

By continuing to explore and refine these approaches, clinicians can offer more effective and predictable dental rehabilitation for irradiated head and neck cancer patients, ultimately improving their long-term health and quality of life.

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