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Dental implants in patients with oro-facial cancers following irradiation treatment – a review of the literature

Implanty stomatologiczne u pacjentów z nowotworem części twarzowej czaszki i po radioterapii – przegląd piśmiennictwa

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Summary

Prosthetic rehabilitation of patients treated for head and neck cancers using dental implants is a challenging task.

To explore the literature concerning the effectiveness and success of implant rehabilitation in irradiated patients.

Research was conducted on MEDLINE via PubMed. The MeSH keywords used were «Radiotherapy»[MeSH], »Dental Implants» [MeSH], «Treatment Outcome»[MeSH], and «Osseointegration»[MeSH]. A combination of these words gave three Boolean equations: («Radiotherapy» [MeSH]) AND «Dental Implants» [MeSH]), («Radiotherapy» [MeSH]) AND «Dental Implants» [MeSH] AND «Treatment Outcome» [MeSH]), («Osseointegration» [MeSH]) AND «Dental Implants» [MeSH]) AND «Radiotherapy» [MeSH]).

The search on Pub Med combined with a manual search gave 361 articles. After the application of the inclusion and exclusion criteria, 54 articles were retained and analysed. The selected articles presented different types of studies. The total number of patients in the selected articles

Streszczenie

Rehabilitacja protetyczna pacjentów leczonych z powodu nowotworów głowy i szyi z wykorzystaniem implantów stomatologicznych jest trudnym zadaniem.

Celem niniejszej pracy było zapoznanie się z literaturą dotyczącą skuteczności i powodzenia rehabilitacji implantologicznej u pacjentów poddanych radioterapii.

Badania przeprowadzono w bazie MEDLINE za pośrednictwem PubMed. Użyte słowa kluczowe MeSH to „radioterapia" [MeSH], „implanty stomatologiczne" [MeSH], „wynik leczenia" [MeSH] i „osseointegracja" [MeSH]. Połączenie tych słów dało trzy równania Boole'a: („radioterapia" [MeSH]) and „implanty stomatologiczne" [MeSH]), („radioterapia" [MeSH]) and „implanty stomatologiczne" [MeSH]) and „wynik leczenia" [MeSH]) ((„osseointegracja" [MeSH]) and „implanty stomatologiczne" [MeSH]) and „radioterapia" [MeSH]).

Przeszukanie bazy Pub Med połączone z wyszukiwaniem ręcznym dało 361 artykułów. Po zastosowaniu kryteriów włączenia i wykluczenia, wybrano i przeanalizowano 54 artykuły. Wybrane

was 16994. All these patients were treated with radiotherapy and variable doses ranging from 50 to 65 Gy. The implant rehabilitation is practised either at the time of the ablative surgery of the tumour, before the radiotherapy, or after the radiotherapy, with a respected time limit between the irradiation procedure and implant surgery. Hyperbaric oxygen therapy was used in most of the retained articles. The success of implant therapy reached 100% in the majority of cases.

Radiotherapy is no longer concerned as a contraindication to implant therapy. It is practised more and more often these days but it is necessary to ensure good follow-up of patients to avoid any risk of osteoradionecrosis, which leads to the loss of implants.

artykuły prezentowały różne rodzaje badań. Łączna liczba pacjentów w wybranych artykułach wyniosła 16 994 i wszyscy byli leczeni radioterapią przy zmiennych dawkach od 50 do 65 Gy. Rehabilitacja implantologiczna jest praktykowana albo w momencie ablacyjnego zabiegu usunięcia guza, przed radioterapią, albo po radioterapii, z zachowaniem limitu czasowego między napromieniowaniem a zabiegiem wszczepienia implantu. W większości analizowanych przypadków zastosowano tlenoterapię hiperbaryczną, a skuteczność terapii implantologicznej osiągnęła 100%.

Radioterapia nie jest już uznawana za przeciwwskazanie do implantacji i jest obecnie coraz częściej stosowana, jednak konieczne jest zapewnienie pacjentom odpowiedniej opieki, aby uniknąć ryzyka osteoradionekrozy, która prowadzi do utraty implantów.

Introduction

Nowadays, most of oro-facial cancers are treated with surgery, radiotherapy, chemotherapy, or a combination of these modalities. However, these treatments are associated with a range of local and general complications. Radiotherapy is often considered the first-line treatment for patients with head and neck cancers and may also serve as an adjunct to surgical excision.[1]

Dental rehabilitation with conventional prostheses may be hampered because reconstructive surgery changes oral anatomy, and radiotherapy results in vulnerable mucosa, xerostomia and bone healing disturbances. Therefore, conventional prosthetic rehabilitation may not have been satisfying for many patients and may not even be possible. In such situations, dental implants were potentially a more effective option for oral rehabilitation, improving mastication, aesthetics and phonation.[2]

Head and neck radiotherapy was originally considered to be a contraindication to dental implant placement. However, the need for optimal rehabilitation of cancer patients has challenged this position.[2]

Today, we are faced with the question: "Is implant rehabilitation possible in patients who have undergone radiotherapy for the treatment of head and neck cancers?"

This systematic review of the literature aimed to investigate the parameters influencing the success of implant surgery, as well as implant-supported prostheses, whether fixed or removable, in patients treated with radiotherapy.

Materials and methods

A systematic review of the literature exploring the Medline database was performed using PubMed. The search strategy was developed using the MeSH words "Radiotherapy"[MeSH]; "Dental Implants"

[MeSH]; "Treatment Outcome" [MeSH], and "Osseointegration" [MeSH]. These terms were associated into different Boolean formulas ("Radiotherapy" [Mesh] AND "Dental Implants" [MeSH]), ("Radiotherapy" [MeSH] AND "Dental Implants" [MeSH]) AND "Treatment Outcome" [MeSH]), ("Osseointegration" [MeSH] AND "Dental Implants" [MeSH]) AND "Radiotherapy" [MeSH])).

Manual research was also performed. The literature research was started in May 2022, and the final update of the search was checked in January 2025.

All articles were included except for the articles that were not published in French or English and those that did not treat the subject of dental implants in irradiated patients with oro-facial cancers.

Results

The total number of articles found was 361. At the selection stage, 108 of these articles were excluded because they were identified as duplicates, 3 articles were excluded because of the language, and 48 articles were not available. After reading the articles, 148 articles were still excluded because they did not meet the objectives of this review. A total of 54 articles were retained for this study.

The methodology adopted for the selection of articles is described in the diagram in Figure 1.

The total number of patients was 16994. The age range of the patients studied varied between 26 and 80 years for 36.8% of patients. For the 63.2%, the age was not mentioned.

The patients' gender was specified in 25 articles. For 1549 patients: 719 (46.41%) were male and 830 (53.58%) were female.

Table 1 lists the oral tumours described in the selected articles.

For 32.14% of the population, the type of cancer was not specified. For the 45.24%, the cause of radiotherapy was not mentioned.

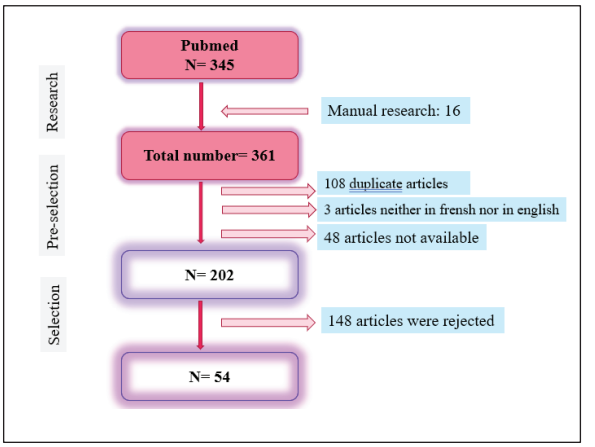

Fig. 1. The methodology adopted for the selection of articles.

The doses of radiotherapy administered to patients varied between 10Gy and 950Gy. The most commonly used doses were between 50Gy and 65Gy.

The total number of implants was 46811, which were placed at the maxillary (3117

Table 1. Oral tumours

Squamous cell carcinoma	**18,04%**
Ameloblastoma	0.43%
Adenoid cystic carcinoma	1.25%
Histyocytosis X	0.14%
Osteosarcoma	0.31%
Basal cell carcinoma	0.16%
Tumour of the floor of the mouth	0.29%
Tumour of the tongue	0.31%
Oropharyngeal carcinoma	1.04%
Nasopharyngeal carcinoma	0.98%
Rhabdomyosarcoma	0.12%
Cheek/parotid gland	0.07%
Palatine tonsils	0.1%
Others	0.08%

implants) and mandibular arches (12606 implants); 29536 implants were placed in the maxilla and the mandible without mentioning the site of placement.

The implant surgery was performed after radiotherapy, before radiotherapy, and at the time of ablative surgery of the tumour. For implants placed before radiotherapy, the time interval varied between 6 weeks and 13 months. For implants placed after radiotherapy, the time interval varied between one month and 22 years. For implants placed at the time of surgery, the authors recommended the waiting period of 6 weeks before starting radiotherapy.

Twenty studies reported the use of hyperbaric oxygen therapy.

The average healing time (loading) was between 4 and 9 months for mandibular implants and 6 to 8 months for the maxillary ones.

The follow-up period of the implants varied in the studied articles between 6 months and 14 years. The success or failure rate varied according to the time of implant placement. For implants placed at the time of surgery, the success rate varied from 93% to 100%.[3,4] For implants placed before radiotherapy, the success rate of implants varied from 60% to 97% after a period of 6 years.[5] For implants placed after radiotherapy, the success rate varied from 57% to 100% after a follow-up period of 10 years.[6]

Discussion

The selection of the patients is essential, especially if the patient has been previously irradiated. Before any implant surgery, taking medical history, a clinical, and a radiological evaluation should be performed. They are an integral part of any therapeutic decision.[7] The preoperative clinical examination and radiological evaluation follow standard procedures. Obviously, the patient must be free of any evidence of residual or recurrent tumour before implant placement. Smoking cessation is also important.[8]

Informed consent should include a discussion of the benefits, harms and risks, such as jaw fracture due to osteoradionecrosis, development of tumour recurrence, early or delayed non-integration of implants and soft tissue problems.[8]

The mean radiation dose at the implant site was identified as an independent prognostic factor for implant survival. The highest failure rate reported in the studies is related to doses above 65Gy.[9,10] In contrast, successful implant rehabilitation was diagnosed in a review by *Granström* et al. in patients who received doses above 65Gy.[11] Even *Schliephake* et al. found a higher implant survival in patients who had received 60Gy (84.6%) compared to those who had received 32Gy (43%).[12]

However, this success cannot be generalized to all cases, as the failure rate remained high with doses above 65Gy.[13,14] According to *Peter M* et al., high doses of radiation above 60Gy were reported to lead to chronic complications such as radioxerostomia, altered wound healing and osteoradionecrosis risk, which may also be the cause of implant failure.[15]

It was demonstrated that dental implants can be safely considered when the mean radiation dose is lower than 38Gy.[16] For doses of 50Gy to 65Gy, the success rate of osseointegrated dental implants was satisfactory. Exploring our studies, it seemed reasonable to assume that radiation therapy (50-65Gy) was not a contraindication to implant surgery, but it should be performed with great care and caution.[8,17]

Several studies have been carried out to compare implant survival in irradiated patients according to the maxillary or mandibular implant placement. In the various studies analysed in a systematic review by *Colella G* et al., they mentioned that implants placed in the maxillary bone had a higher failure rate than those placed in the mandible, with an

average implant failure of 4.4% in the mandible compared to 17.5% in the maxilla.[18] According to *Kende PP* et al., the implant success rate on the mandibular bone (94.5%) was higher than that on the maxillary bone (70.4%).[19]

According to *Niimi* et al., the success of implants in the mandible is more predictable than in the maxilla, even with the addition of hyperbaric oxygen therapy before implantation.[20]

The mandible, because of its density, seemed to be able to integrate implants; it was relatively more radio-resistant compared to the maxilla. The mandible was denser, so the implant was more stable and integrated more easily into the bone.[2]

In addition, vascularization at the maxillary level was greater compared to the mandible, which explains the high failure rate at the maxillary bone level. However, some studies have reported similar survival rates of dental implants in the maxilla and the mandible.[21] Implants' success rate was higher in the anterior part of the mandible than in the posterior region, as reported by *Budulla* et al.[22] and *Brauner E* et al.[13] This would be due to the fact that the bone is denser anteriorly, and therefore provides a better primary stability.[13] Mandibular symphysis was very rarely affected by radiation. Therefore, it had a very high rate of implant success. However, the premolar and molar regions were much more affected and received much larger doses, resulting in more failures.[22]

According to *Mattila V* et al., implant survival was not significantly influenced by radiation therapy. In grafted bone, implant survival was significantly inferior to that in native bone.[23]

The optimal timing of implant placement in patients treated with radiotherapy was controversial.

Authors recommend implant insertion after ablative procedure.[24] This is advantageous because the initial healing of the implant (osseointegration) occurs before radiation, and the risk of late complications such as the development of osteoradionecrosis is reduced.[24]

Post-implantation radiotherapy carries an increased risk of osteoradionecrosis in the absence of mucosal coverage on the implants at the time of radiotherapy.[21] Furthermore, the patient's vital prognosis was completely unknown at this stage of treatment.[5]

Implant placement can be done at the time of ablative surgery, and a high success rate has been demonstrated. It varies from 93% to 100%.[3,4] In fact, the placement of dental implants during ablative surgery enables placement in healthy bone and facilitates osseointegration of the implants during the period between surgery and radiation therapy.[21]

Implant placement can also be performed after radiotherapy with a delay of 6 to 18 months. The advantage of implant placement after radiotherapy was that the anatomical situation, the residual function, and the prognosis could be taken into account in the decision of implant therapy.[25] Nevertheless, the risk of osteoradionecrosis following implant surgery cannot be excluded.[21]

The time between irradiation and implant surgery may influence the survival of dental implants. However, the recommendations for an optimal time interval are inconsistent.

For implants placed after radiation therapy, many investigators have recommended a waiting period of 6 to 12 months after radiotherapy before starting implant rehabilitation.[10,19,26,27]

Other investigators have proposed a delay of two years.[28,29]

Factors that can affect the choice of rehabilitation period are the risk of tumour recurrence, the risk of osteoradionecrosis, the implant survival, and the patient's consent. According to *Marx* and *Johnson*, the risk of surgical complications was low from 6 months to 18 months after radiotherapy, and then increased again.[30] *Sammartino* et al.

recommended waiting at least 12 months for the best clinical results.[31]

Hyperbaric oxygen therapy has been used for the treatment and prevention of ORN. The protocol described by *Marx* and *Johnson* for ORN prophylaxis in at-risk patients consisted of 20 to 30 sessions (dives) at 2.4Atm with ATA with 100% oxygen for 90 minutes before surgical procedures and 10 post-operative dives after completion of extensive surgical procedures.[32]

The main effect of hyperbaric oxygen therapy was the hyper-oxygenation of irradiated ischemic bone. Its high efficacy in therapy and prophylaxis of osteoradionecrosis has been consistently demonstrated.[15] Healing is promoted by stimulating angiogenesis, fibroblast proliferation, collagen synthesis and crosslinking, and enhancing antimicrobial actions of leukocytes, thus providing resistance to infections. At elevated pressure, oxygen acts as a growth factor, thereby stimulating osseointegration, increasing the bone implant contact (BIC) and the removal torque needed to pull out titanium implants placed in irradiated bone.[9]

Taylor et al. recommended that hyperbaric oxygen therapy can be considered for use prophylactically for patients who have received more than 50Gy to the implant site to hopefully promote increased vascularity and reduce the risk of potential complications.[33]

It was demonstrated that hyperbaric oxygen appears to be essential for ensuring upper maxillary success rates approaching those obtained in the mandible.[29]

Jacobson et al. stated that the period of healing in irradiated jaws was longer than in non-irradiated bone. Therefore, they advocated a healing period of 6-9 months before loading the implants.[15]

Immediate loading took place more and more, but remained subject to special conditions. Therefore, for irradiated patients, it was contraindicated because of the disruption in bone remodeling caused by radiotherapy. It was preferable to act in two surgical steps with a longer set-up.[33]

Conclusions

Regarding the growing interest of dentists to provide effective implant rehabilitation in patients with head and neck cancers treated with radiotherapy, a systematic review was proposed to address the objective based on the success of implant placement in irradiated patients.

This literature review led to the following deductions:

1. The radiation dose affects the success of implant therapy; the higher the doses, the higher the risk of osteoradionecrosis, which impairs osseointegration of implants and leads to their loss. Implants can be placed with doses ranging from 50 to 65Gy without risk of loss or osteoradionecrosis.
2. The timing of implant placement depends on the clinical situation: during ablative tumour surgery, before radiation therapy, or after radiation therapy. This does not affect implant survival because each moment has both advantages and disadvantages.
3. The site of implantation differed between the maxillary bone and the mandible; the highest number of failures was observed at the maxillary level, but this rate remains very low, which does not contraindicate the placement of an implant at the maxillary level.
4. A period of time must be allowed between irradiation and implant placement. The duration of this period varied according to several authors, but must be more than or equal to six months.
5. Hyperbaric oxygen therapy was used as a means of preventing osteoradionecrosis and with an irradiation dose of more than 50Gy,

but this treatment was not widely used because of its contraindications and high cost.

6. Implant loading should occur after a period of implant placement to ensure proper bone and mucosal healing of the peri-implant tissues. The duration of this period was also variable; it was preferable to wait six months after implant therapy.

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