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Review

The use of implant retained mandibular prostheses in the oral rehabilitation of head and neck cancer patients. A review and rationale for treatment planning

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Summary Surgical treatment of malignancies in the oral cavity (tongue, floor of the mouth, alveolus, buccal sulcus, oropharynx) often results in an unfavourable anatomic situation for prosthodontic rehabilitation. The outcome is a severe disturbance of oral functioning despite the improved surgical techniques for reconstruction that are currently available. Radiotherapy, which often is applied postsurgically, worsens oral functioning in many cases. Main problems that may hamper proper prosthodontic rehabilitation of these patients include a severe reduction of the neutral zone, an impaired function of the tongue, and a very poor load-bearing capacity of the remaining soft tissues and mandibular bone. Many of these problems can, at least in part, be diminished by the use of endosseous oral implants. These implants can contribute to the stabilisation of the prostheses and intercept the main part of the occlusal loading. Surgical interventions *after* radiotherapy are preferably avoided because of compromised healing, which may lead to development of radionecrosis of soft tissues and bone as well as to increased implant loss. If surgical treatment after radiotherapy is indicated, measures to prevent implant loss and development of radionecrosis have to be considered e.g. antibiotic prophylaxis and/or pre-treatment with hyperbaric oxygen (HBO). To avoid this problem, implant insertion *during* ablative surgery has to be taken into consideration if postoperative radiotherapy is scheduled or possibly will be applied. This approach is in need of a thorough pre-surgical examination and multidisciplinary consultation for a well-established treatment planning. The primary curative intent of the oncological treatment and the prognosis for later prosthodontic rehabilitation have to be taken into account too.

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Introduction

Surgical treatment of malignancies involving the oral cavity often results in an altered anatomical situation, which may severely hamper oral functioning. Surgical treatment is often combined with radiotherapy, which further worsens oral functioning. Amongst others salivary secretion is reduced, and speech, chewing (mastication), swallowing and aesthetics are in general impaired.[1–9] Due to the changed intra-oral conditions the possibilities to obtain proper stability and retention of a mandibular prosthesis are seriously at risk.[1,9–12] For example, particularly after radiotherapy, the load-bearing capacity of both the native and reconstructed tissues is compromised. [7,10,13,14]

Until recently neither reconstructive surgery nor conventional prosthodontic techniques were capable to address these problems successfully.[15,16] A proper choice of reconstruction techniques in combination with implant supported or retained prosthodontics probably can attribute to better functional results in the oral rehabilitation of these patients.[6,8,10,12,17–26] As a first effect, implants are used with increasing frequency for prosthetic support in patients who are treated for malignancies in the lower region of the oral cavity.[9,11,13,20,26,27] This includes reconstruction of the mandible and insertion of implants in patients who have been treated with radiotherapy, in spite of the well-documented adverse biologic changes that occur when soft and osseous tissues have been exposed to ionising radiation.[3,4,7,20,28–31]

Irradiated sites are thought to be at significant risk for tissue necrosis and loss of implants, if subjected to implant surgery.[32] Thus, the appropriateness of using implants in irradiated patients has been seriously questioned.[18] Because of the radiation hazards mentioned, it might be reasonable to place implants prior to postoperative radiotherapy, preferably simultaneously with ablative surgery.[2,15,27,33]

In this paper the literature regarding the treatment outcome of the use of implants for oral rehabilitation in edentulous patients within the scope of the oncological treatment in the lower region of the oral cavity is reviewed and a rationale for treatment planning is given.

Methods

The human studies published in international English language peer reviewed literature regarding the treatment outcome of the use of implants for oral rehabilitation in edentulous patients after ablative tumour surgery in the lower region of the oral cavity are reviewed. The search terms included head and neck neoplasm's, dental implants, radiotherapy, hyperbaric oxygen therapy (HBO) and edentulous mandible. Publications presented in abstract form were ignored and case reports were excluded. Due to differences in experimental set-up and (or) methodological shortcomings, it was not possible to execute a meta-analysis including a sufficient number of studies. In many studies a rather low number of patients is described.

Placement of implants during ablative tumour surgery

Pre-ablative treatment planning

Prosthodontic rehabilitation of an edentulous oncology patient should not be limited to the post-treatment stage, but has to be considered already in the planning of the cancer treatment. It should be an integral part of the treatment plan of a particular patient and drawn up in full co-operation with the other members of the head and neck oncology team.[9,13,15,27,34]

The oral status has to be recorded including the patient's history of functioning with his prostheses. Prostheses have to be checked for fit, stability, retention and occlusion. Special attention and experience of the prosthodontist is needed to estimate the possible effects of the chosen surgical and (or) radiotherapeutic treatment on post-treatment oral functioning. Especially the effects on the neutral zone (the dynamic space between the lips, the cheeks and the tongue that is available for a prosthesis) and the possible deviation of the mandible after surgery have to be taken into account.[9,27]

The head and neck oncology team decides on the appropriate oncological treatment. This treatment is based on the characteristics of the tumour (clinical classification, pathology and imaging), the estimated size of the defect after ablative surgery, the type of surgical reconstruction to be used to close the defect and to restore function, and the possible need for radiotherapy.[35]

Intra-oral defects caused by ablative surgery of malignancies in the lower region of the oral cavity mostly require a surgical reconstruction with soft tissue flaps without a need for bony reconstruction. Main problems of most soft tissue flaps are their bulky volume and absence of intrinsic mobility, which can severely restrict the neutral zone and

thus complicate functioning of a mandibular prosthesis. In case of smaller tumours primary closure of the defect often can be achieved. Even this can result in a diminished mobility of the tongue, which may rise problems with e.g. speech (articulation) and swallowing, and again a restricted neutral zone due to loss of sulcular depth.[36] In case of loss of mandibular continuity, primary bony reconstruction of the defect is strongly preferred to restore function and to prevent soft tissue collapse.[8,24,28,37,38] Unfortunately, this can not always be realised, mostly due to patient related factors like advanced vascular disease or poor general health.

Therefore, before ablative surgery is performed, it has to be assessed whether implants might be of benefit for oral rehabilitation in the given situation.

Considerations regarding placement of implants during ablative surgery

Especially when it is likely that postoperative radiotherapy is indicated, some authors advice to insert implants immediately following the ablative procedure in the same session (Figs. 1 and 2).[2,15,33,39,40] The major advantages of implant placement during ablative surgery reported in literature include:[15,25,38]

- Initial implant healing (osseointegration) takes place before irradiation;
- Implant-surgery in a due to radiotherapy compromised area is avoided thus reducing the risk of late complications, such as development of osteoradionecrosis;
- The patient can benefit from the support of the implants in an earlier stage after treatment. Among others this support is important for the rehabilitation of speech and swallowing;
- The patient is saved from another surgical intervention;
- There is no need for adjunctive HBO therapy.

A pre-requisite of successful implant placement and prosthetic rehabilitation is proper handling of the soft tissues. Tension free closure of the surgical defect, either by primary closure or vascularised (free) flaps, has to be achieved to minimise the risk on development of dehiscence of bone near the implants.[41] A dehiscence may lead to improper implant healing and even to loss of the implants.[42] Attention has also to be paid to mobility of the oral tissues to warrant proper functioning as impeded mobility of the oral tissues compromises the function of even the best prosthetic rehabilitation.[43]

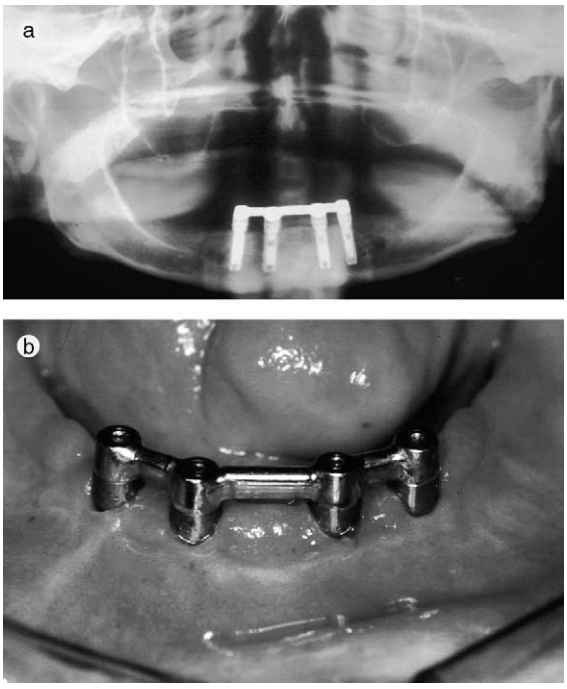

Figure 1 A 50 years old male patient with a T2N1 squamous cell carcinoma of the floor of the mouth. The patient underwent wide local excision of the tumour and a unilateral supra-omohyoid neck dissection. Four implants were inserted simultaneously with the ablative procedure. After six weeks a fractionated radiotherapy scheme was started up to a cumulative dose of 64 Gy. (a) Orthopantomogram 1.5 years after surgery showing four implants and the suprastructure. (b) Clinical view showing the implants and suprastructure.

A major disadvantage of immediate implant insertion concerns the risk of improper implant positioning when ablative surgery will result in gross alterations in the anatomical situation and/or intermaxillary relationship, e.g. after mandibular continuity resections. Improperly positioned implants impair the prosthodontic treatment and can sometimes even not be used in the prosthodontic rehabilitation of a patient.[6,15,19,22,35,44] As a rule it is better to refrain from implantation during ablative surgery when proper positioning is doubted.

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 the implantation during ablative surgery.[15] These disadvantages are assessed to be of minor importance, especially when compared to the high risk on harmful tissue reactions to be encountered in case of implantation after radiotherapy.[45] In addition, a two-stage technique is advocated to minimise the risk on early post-ablative complications

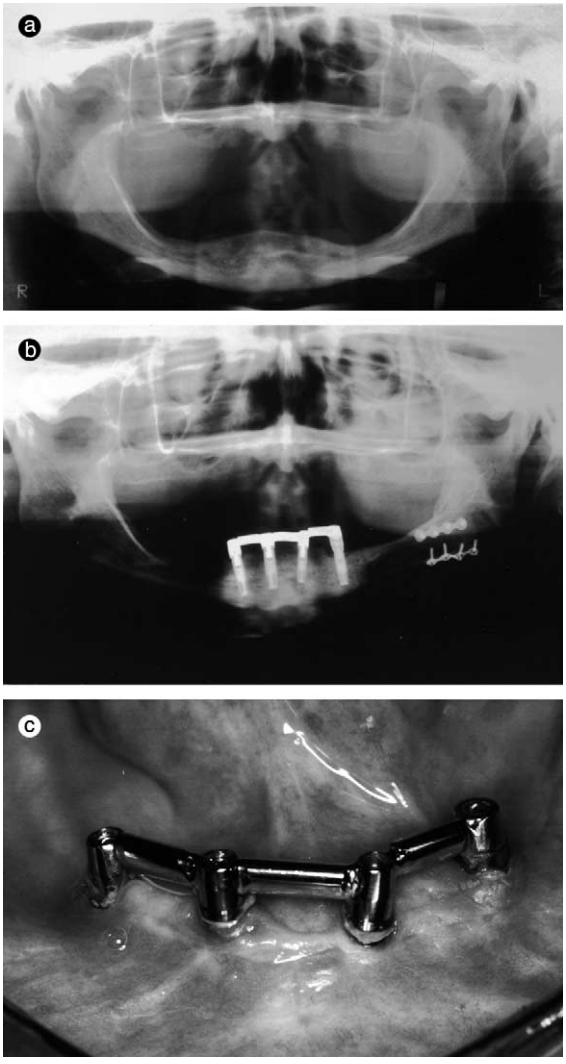

Figure 2 A 54 years old female with a T4N0 squamous cell carcinoma of the mandibular gingiva. The patient was treated with wide local excision of the tumour, including a continuity resection of the mandible, and a unilateral modified radical neck dissection. The continuity of the mandible was restored with a free vascularized fibular transplant. Simultaneously four implants were inserted in the ventral part of the mandible. After six weeks the patient was subjected to a fractionated radiotherapy schedule up to a cumulative dose of 70 Gy. (a) Orthopantomogram showing the situation before ablative surgery. The tumour did not invade the mandibular bone. (b) Orthopantomogram 2 years after ablative surgery. The continuity of the mandible was restored with a fibular transplant. The four implants were inserted per ablationem. (c) Clinical view showing the implants and suprastructure.

as then the implants are covered by mucosa during radiation therapy.[46] Finally, by using multiple radiation fields backscatter doses can be minimised and are of minor concern.[31,47]

The last disadvantage of implantation during ablative surgery to be mentioned is the risk that inserted implants will not be used due to early tumour recurrence. This disadvantage is of minor importance because of the low morbidity of implant treatment in the lower jaw. Therefore, if there is a fair chance that these patients may benefit from an improved quality of life related to an implant supported prosthesis, it is recommended to also consider this procedure in advanced tumour cases that will be treated with curative intent.

Number of implants and healing time

According to the literature in patients with malignancies involving the lower region of the oral cavity a minimum of four implants is needed to achieve maximal implant support for the prosthesis and to relieve the vulnerable underlying soft-tissues, especially after radiotherapy.[6,14] Like in non-oncological cases, in non-irradiated head and neck cancer patients abutment connection can be performed after 3 months. If the patient has received irradiation in the implant region it is advised to wait 6 months after the implant placement before the abutment connection.[42,48,49] This way the implants are given some extra time for osseointegration and the early soft-tissue radiation effects will be resolved at the time of abutment connection.[1] It is questionable, however, whether the implants need this extra time since most of the osseointegration has taken place before the start of radiotherapy.[15,33,50] The optimal head and neck oncology treatment related healing time of implants before loading is still in need of further research. By contrast, there is consensus that prosthodontic rehabilitation can start two weeks after abutment connection.

Placement of implants after ablative tumour surgery

Postablative treatment planning

Edentulous patients who have completed their oncological treatment for oral cancer often experience great trouble with prosthodontic rehabilitation.[16,42] Problems often encountered are an impaired function of the tongue, change in volume of the tongue, and lack of motor and sensory innervation.[8,43,51] The decreased mobility of the oral tissues may give rise to problems with food control and transportation during chewing and

swallowing and cause decreased intelligibility of speech. These problems are worsened if the sensibility in the defect region is lost too.[22] An increase of the vertical dimension by introduction of a mandibular prosthesis even might lead to more severe complaints, because the tongue might have lost its ability to get in contact with the palate.[35] This may impair speech and swallowing. Also control of the foodbolus by the tongue during chewing is restricted.[8,35,51] Therefore some patients do not wear their mandibular prosthesis during eating as they experience eating without prosthesis less troublesome.

It has been reported that these problems can be solved to some extent by lowering of the palatal contour of the maxillary prosthesis.[35] To improve the mobility of the tongue a surgical release procedure (Steinhauser) can be considered,[36] but especially in the irradiated patient, the vascularity of flaps should not be jeopardised. Furthermore, due to reconstruction with bulky flaps as well as primary closure of defects the neutral zone can be severely compromised.[9,52]

Many patients suffer from a reduced salivary secretion after irradiation, resulting in difficulties with amongst others chewing, swallowing and speech.[3,4] The vulnerability of the atrophic oral mucosa, another effect of irradiation, is enhanced by the absence of the protective layer of saliva. Prosthetic loading of this atrophic mucosa is often not well tolerated, especially when the mandibular prosthesis is not stable.[25,33,53,54]

Considerations regarding placement of implants after ablative surgery

From the literature, it can be derived that implant-retained mandibular overdentures can strongly reduce the problems with stability and retention of a denture and relief the underlying soft tissues, particularly if the occlusal load is beared by the implants.[6,26,55] As in the 'non-oncological' patient, the bone in the interforaminal area of the mandible is available for implant insertion, as is the bone above the alveolar nerve in the posterior mandible when minimal resorption of the alveolar bone has occurred.[7,11] If due to the ablative procedure (e.g. partial mandibulectomy) the alveolar bone has been denervated, the whole height of the remaining part of the mandible on the affected site can be used for implant placement.[28] Also, bone transplanted to restore mandibular continuity can be used for implant restoration (Fig. 3).[11,24,28,57]

Patients who underwent a partial mandibulectomy without bony reconstruction might need a secondary reconstruction before implantation in the defect site can be considered to be a proper option.[12,28] In some cases, the soft tissues have been surgically reconstructed and continuity has been re-established with a reconstruction plate or a bone graft with an insufficient volume (e.g. costal grafts) for reliable implant placement. Another often encountered problem in these patients is the lack of soft tissues and scar formation in the area needed to cover a bone graft. This lack of soft tissues bears the increased risk of wound dehiscence following reconstruction and thus the increased risk on loss of grafted bone.[16,57] In patients not treated with radiotherapy in the area to be reconstructed, free bone grafts, e.g. from the iliac crest, have been shown to be a good option. In irradiated patients, however, free grafts have to be avoided because of the risk of development of osteoradionecrosis.[57,58] In these patients vascularised free flaps (fibula, scapula or ilium) or a "Marx procedure" (free bone graft in a crib with pre- and postoperative HBO) have to be considered.[24,37,41,57–60] The bulky volume of vascularised (free) flaps not uncommonly interferes with functioning of an (implant-retained) overdenture. Therefore, there is often a need for correction of grafted tissues during implant insertion or abutment connection.

After any form of re-establishment of continuity of the mandible, fabrication of a prosthetic set-up followed by a surgical template is recommended for planning of the proper location and angulation of the implants.[6,33–35] Improperly positioned or angulated implants impair the prosthodontic treatment and can sometimes even not be used in the prosthodontic rehabilitation of such a patient.[6,22] The presence of oral mucosa surrounding the implants is preferred to skin(grafts), because more problems of peri-implant skin tissue are encountered in comparison to mucosal tissue, both during healing and after abutment connection.[30,34,53,61,62] Occasionally the free mucosa or skin present around the implants is replaced by palatal mucosal grafts.[25,34,59,63,64] When two-stage implants are used a second operative procedure in irradiated tissue is necessary.

The use of oral implants in irradiated tissue is not considered to be contra-indicated, although it has been reported that the risk on implant failure is increased with losses up to 35% (mean 13.6%, range 0—36%).[7,10,11,16,17,20,23,24,28,30,33,34,39,42,44,49,58,63,65–75] In non-irradiated mandibles the implant survival rate is, in most studies, at least 90% (mean 96.1%, range 74.8—100%).[56,76]

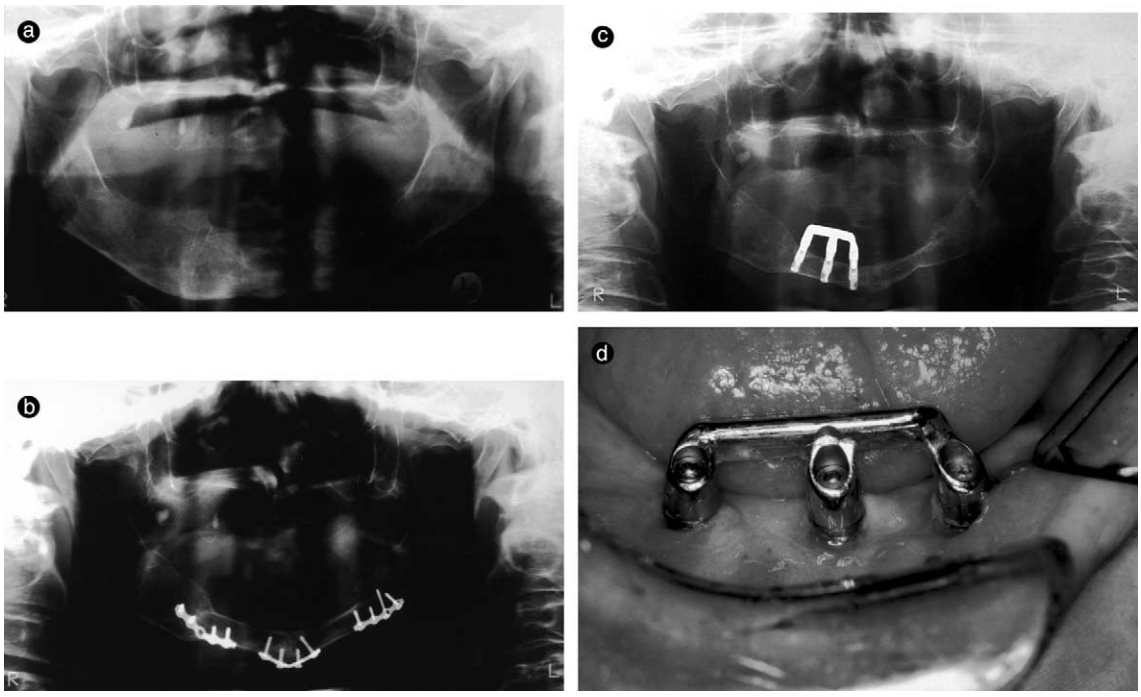

Figure 3 A 64 years old female with a T4N0 squamous cell carcinoma of the mandibular gingiva. The patient was treated with wide local excision of the tumour, including a continuity resection of the mandible, and bilateral supra-omohyoid neck dissection. The continuity of the mandible was restored with a free vascularized fibular transplant. Six weeks after the ablative procedure the patient received fractionated radiotherapy up to a cumulative dose of 60 Gy. After three years five implants were inserted in the neo-mandible (fibula). This procedure was performed using antibiotic prophylaxis, but without HBO. Shortly after abutment connection two implants were lost. (a) Orthopantomogram before ablative surgery. Osteolysis of mandibular bone in the symphyseal region is clearly visible. (b) Orthopantomogram three years after ablative surgery. The continuity of the mandible was restored with a fibular transplant. (c) Orthopantomogram 1.5 years after insertion of the implants showing the three remaining implants and the suprastructure. (d) Clinical view showing the implants and suprastructure.

Handling of irradiated tissues

General agreement exists about the obligatory use of a gentle surgical technique with minimal reflection of periosteum and the use of perioperative antibiotics to prevent wound healing disturbances.[30,32,48] Additional measures to prevent implant loss or development of osteoradionecrosis, such as a pre-treatment with HBO, have to be considered. HBO treatment claims to permanently improve the vascularisation of the bone and is assumed to have a positive effect on osseointegration of the implants.[72,77–79] Preferably one-stage implants are used, thus avoiding the need of a second surgical procedure (abutment connection) and a second period of HBO.

The negative effects of radiation on osseointegration have been reported to depend on the location of implants, and the dose and fractionation of radiotherapy.[32,49,80] In general, doses over 40—50 Gy are thought to significantly impair the healing capacity of the bone with an inherent increase of the risk on complications when performing surgery.[64,81] Therefore, for implant placement after radiation therapy at intra-oral sites being treated with total doses exceeding 50 Gy, the use of HBO for prevention of late complications has to be taken in consideration.[30,49,53,64] The real value and necessity of the HBO treatment in such cases still has to be proven in prospective clinical studies, however.[67,82,83] Timing of the implantation procedure with regard to the effects of irradiation on jawbone remains inconclusive. There are reports about an improvement in the bone healing capacity over a 12-months period following irradiation,[29] while others report a continuously progressive loss of capillaries in the mandible following irradiation.[84] In agreement with the study of Marx is the study of Granström reporting the longer the period between irradiation and implantation the higher the risk on implant loss.[45] Latter authors recommend implant insertion in a so called "window" between

1 and 6 months after radiation therapy.[45,84] In this period the early radiation effects are resolved and long-term vascular changes associated with cancericidal radiation treatment may not have taken place. Also the bone is still relatively well vascularised.

Number of implants and healing time

In irradiated patients a minimum of four implants is recommended. These implants should be placed in optimally spaced locations for the best possible spread of occlusal loading.[14,35] When no radiotherapy is applied and lack of stabilisation of the mandibular prosthesis is the only problem encountered an implant-mucosal borne prosthesis, i.e. a mandibular overdenture supported by two implants, can be sufficient to restore function.[56] After implant placement in irradiated sites in the mandible it generally is advised to wait 4–6 months before the abutment connection to allow the implants for some extra time for osseointegration.[11,30,33,42,48,49,85]

Proposed treatment regimen

As described in the previous paragraphs, in edentulous patients the loss of hard and soft tissues after ablative surgery of tumours of the mandible, tongue or floor of the mouth might create severe problems in oral functioning. These problems often cannot be restored with conventional surgical or prosthodontic techniques. Radiation therapy worsens this situation and makes rehabilitation even more difficult. Implantology offers the opportunity to improve the oral rehabilitation of these patients by stabilisation of the prosthesis. An implant-supported prosthetic construction diminishes pain and may thus enhance the ability to regain essential functions such as speech, chewing and swallowing. Part of the compromised oral functioning is not prosthesis driven, however, but related to other effects of the cancer treatment including a lack of motor and sensory innervation of the oral tissues and hyposalivation. Therefore, a thorough consideration of the possible advantages and disadvantages is essential in the pre-operative stage.

For optimal treatment planning both maxillofacial prosthodontists and implant surgeons should be members of the multidisciplinary head and neck oncology team. Nowadays the application of implants is considered for all edentulous patients with a malignancy in the lower region of the oral cavity (Fig. 4). It is an integral part of the care for the head and neck oncology patient. If postoperative radiation therapy might be part of the treatment plan, implants are inserted during ablative surgery if possible. Only if the oncological resection includes more than half of the symphyseal region no implants are inserted because of the grossly altered anatomical situation and intermaxillary relationship. This may lead to improper positioning and angulation of the implants in the reconstructed bone. In these cases, for the goal of secondary implant insertion and maximum chances for rehabilitation of function, the continuity of the mandible should be restored immediately, preferably with vascularised bone of sufficient quantity to insert implants in a later stage.

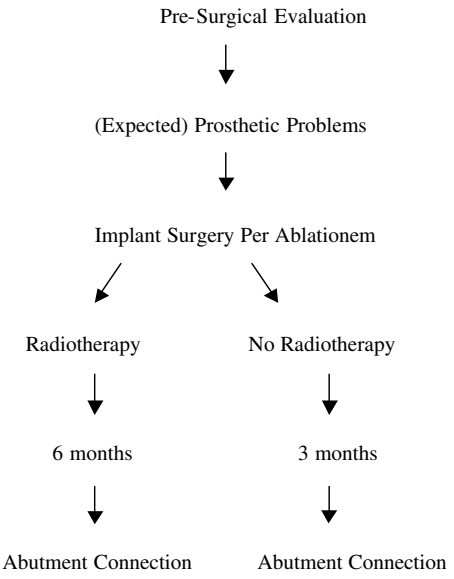

Figure 4 Decision-making process for implant insertion in the mandible per ablationem.

In case of implant placement after fractionated radiotherapy with cumulative doses exceeding 40–50 Gy the application of HBO treatment before implant insertion must be considered for prevention of late complications, such as the development of osteoradionecrosis (Fig. 5). With regard to timing of the implant insertion after radiotherapy no evidence-based recommendations can be given due to lack of scientific evidence. Since most recurrences of oral malignancies manifest itself within one year after initial oncological treatment it may be prudent to wait at least one year with secondary implant placement.

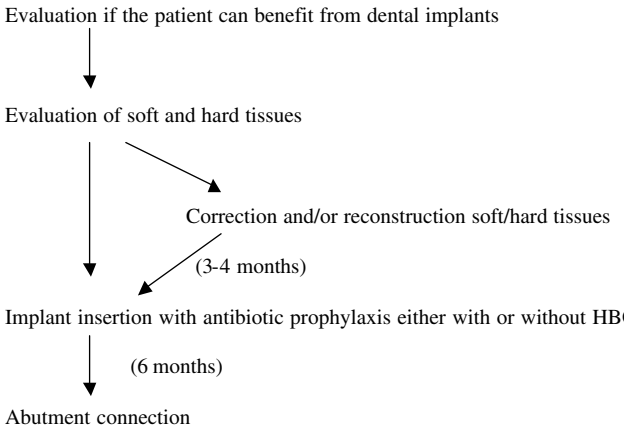

Figure 5 Decision-making process for insertion of implants in the mandible after radiotherapy.

Epilogue

This review shows that there are still shortcomings in scientific evidence about the timing of implant insertion with regard to radiation therapy and about the indications and potential benefit of preventive HBO therapy. Future research should address these issues.

There is a strong tendency towards implant insertion during ablative surgery in order to prevent surgery in irradiated tissue and to shorten the time for functional rehabilitation of the head and neck cancer patient. Implant placement during ablative surgery is doubted in case of loss of continuity of the mandible, even if the continuity of the mandible is restored with a bone transplant. As a rule it is better to refrain from implant placement during ablative surgery when proper positioning is doubted.

One has to keep in mind that an implant-supported prosthesis is not a guarantee for uncompromised oral function posttreatment, but it is considered a significant factor contributing to the well being of these patients.

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