IMPLANT-SUPPORTED BAR OVERDENTURES IN PATIENTS TREATED SURGICALLY FOR UPPER AERODIGESTIVE TRACT CANCER .

Nadine OMEISH[1], Benjamin Pomes[1], and Hélène Citterio[1]

[1]Groupe Hospitalier La Pitié Salpêtrière-Charles Foix

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Abstract

Patients who have undergone upper aerodigestive tract (UADT) cancer surgery are a real challenge in prosthetic rehabilitation. Many clinicians tend to shift towards an implant-supported prosthesis. Thus, we first reviewed a specific type of implant rehabilitation: the connecting bars. Then two clinical cases are described in this article.

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AUTHORSHIP LIST

Nadine OMEISH, DDS, University of Paris, Hospital la Pitié-Salpêtrière APHP

Benjamin POMES, DDS, Hospital Practitionner, Hospital la Pitié-Salpêtrière APHP

Hélène CITTERIO, DDS, PhD, senior lecturer in Prosthodontics

University of Paris, Hospital la Pitié-Salpêtrière APHP

Corresponding author : Nadine OMEISH

Adress : 47-83, Boulevard de l'Hôpital 75013, Paris, FRANCE

Email adress :*nadine.omeish@gmail.com*

Phone number : + 33 6 65 34 72 05

DATA AVAIBILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

DISCLOSURE

The authors declare no conflict of interest.

ABSTRACT

Patients who have undergone upper aerodigestive tract (UADT) cancer surgery are a real challenge in prosthetic rehabilitation. Many clinicians tend to shift towards an implant-supported prosthesis. Thus, we first reviewed a specific type of implant rehabilitation: the connecting bars. Then two clinical cases are described in this article.

KEY CLINICAL MESSAGE

Rehabilitating patients that underwent an UADT cancer surgery with imlant-supported prosthesis using a connecting bar can be the best compromise, on a quality of life level, and a functional and esthetic level.

KEYWORDS

Connecting bar, implants, upper aerodigestive tract cancer, implant-supported prosthesis.

INTRODUCTION

Treatment of patients with cancer of the upper aerodigestive tract (UADT) is based on a resective surgery, and/or radio/chemotherapy. The consequences of such a management are quite serious: they lead to tissue loss (more or less compensated by fibula or scapula grafts), hyposialia or asialia, increased carious and periodontal risks, limitation in mouth opening, and microstomia (1). The prosthetic rehabilitation of this type of patient may be quite challenging for the clinician, due to a « clinical paradox ». Indeed, while the tissue loss aggravated by bone resorption should lead to an increase of the prosthetic space, limitation of mouth opening and microstomia cause labial inocclusion at rest, and finally end up with a reduced occlusal vertical dimension (OVD). Rehabilitation of the occlusal vertical dimension (OVD) is then achieved with the best possible compromise in terms of esthetics, phonetics and function, and is most often reduced compared to the intial pre-trauma situation.

The treatment options allowing to compensate for this tissue loss include complete removable dental prostheses (RDP) either conventional or stabilized with dental implants. When the appropriate indication is selected, the survival rate of a fibula flap would be around 97%, and the implant survival rate around 78%, according to a retrospective study with 11 years of follow up (2). Several implant-supported prosthetic options may be considered according to the clinical situation : a fixed implant-supported prosthesis, a complete removable-fixed dental prosthesis supported by a bar and a counterbar, and a complete removable dental prosthesis stabilized over implants with ball-attachments or a connecting bar (CB). Several types of bars have been described in the scientific literature. The purpose of this article was to present different types of bars and their indications for patients, illustrated by two clinical cases. The different types of bars are described in Table 1, and their indications are displayed in a decision tree in Figure 1.

SELECTING THE NUMBER OF IMPLANTS

Generally, the number of implants recommended either for a fixed implant-supported prosthesis or an implant-supported bar-retained overdenture varies between 4 and 6 implants. Several studies have evaluated patient satisfaction according to the number of implants placed for implant-supported bar-retained removable dentures; however, these studies were performed on patients with no history of UADT cancer. They showed a very good satisfaction rate in patients wearing an implant-supported bar-retained overdenture with 4 to 6 implants (3). With a bar, the implant survival rate would be higher using 6 implants (4) compared to 4 implants. Moreover, the greater the number of implants, the less stress will occur (5,6) on the screws connecting the bar to the implants.

CLINICAL PARAMETERS FOR PLACING A CONNECTING BAR (CB)

In order to choose the most appropriate implant-supported prosthetic rehabilitation, different parameters must be addressed. On an esthetic point of view, if the patient displays a gummy smile or needs lip support, an implant-supported bar-retained overdenture must be considered. Unlike attachments, the connecting bar (CB) is indicated if the implants are not parallel. For some authors, a connecting bar is indicated when the distance between the implant head and the occlusal plane is greater than 11 mm (7).

DESIGN OF THE CONNECTING BAR

Elsyad MA et al. showed that a Hader bar (figure 2) provides overall more axial and non axial retention than a Dolder bar. These 2 types of bars offer poor retention in case of lateral forces (8). Dos Santos MBF. et al demonstrated that a round section bar exerted less tension on the « clips » and prosthetic screws than

the Hader bar. However, the latter would exert less tension on the peri-implant tissues than a round section bar (9).

De la Rosa Castolo G. et al. compared connecting bars with different cross-sections : square, round, rectangular and L-shaped. The square-cut design would deliver the least amount of tension forces to the bone, implants and screws, as opposed to the rectangular cross-section which would deliver the most tension forces (6).

The greater the diameter of the bar, the less bone loss. The shorter the distal cantilever the less bone loss. Furthermore, in case of a distal cantilever, the stress transmitted to the bone is greater with 30°-tilted implants versus straight implants. However, there seems to be no significant difference between the cross-section design of the bars (round, square), and the stress exerted on the implants and on the bone (6). Weinländer M. et al. showed a significant difference between a machined bar and the prefabricated round section bar in terms of prosthetic maintenance (10) : connecting bars would need more maintenance and follow up. A CB-mucosa space of 1 or 2 mm allows better stress distribution on implants and peri-implant bone. Moreover, this minimum distance of 2 mm is recommended for the patient's good oral hygiene maintenance (11). Joshi S. et al. showed that the higher the CB-mucosa distance, the greater the stress on the peri-implant bone. (12)

These studies were performed on 2-implant-retained prostheses. To our knowledge, no study has yet been conducted for 4 or more implants.

THE CONNECTING BAR MATERIAL

Several materials have been investigated *in vitro* such as : titanium, cobalt-chromium, PEEK, fiber-reinforced resin, and zirconia. One study using a finite element model observed that CB material (cobalt-chromium, grade 4 or 5 titanium, and zirconia dioxyde) does not seem to have any mechanical effects on the bone (6).

With 4 mandibular implants, the fiber-reinforced resin CBs seem to deliver less stress to the implants and the peri-implant bone compared to the cobalt-chromium bars (either machined or fabricated conventionally) and the titanium machined bars (13).

The plastic clips seem to exert less tension forces than the gold clips on the prosthetic screws and the peri-implant tissues (9).

CLINICAL CASE N° 1 (figures 3-5 and 8)

A 48 year-old male patient, presenting stabilized hypertension and hypercholesterolemia. A myoblastic type embryonic rhabdomyosarcoma in the right cheek was diagnosed at the age of 2 years. Surgical removal of the tumor and part of the cheek had been performed, combined with curietherapy and multiple chemotherapies. Several reconstructions had been implemented over the years (right jugal reconstruction using a back perforating flap, a scapula free flap, bicommissuroplasty, etc). The patient was referred to us for oral management. He wanted to have a functional and esthetic rehabilitation with prostheses allowing an easy oral hygiene maintenance.

Clinical examination and diagnosis

Extraoral examination of the patient shows a 19 mm limitation of mouth opening between the inferior edge of the upper lip and the upper edge of the lower lip, combined with microstomia and subtotal loss of laxity on the right side. Despite the absence of occlusal wedging, we observe a persisting labial inocclusion at rest, and a concave subnasal profile, combined with collapse of the philtrum. The asymmetrical smile is due to a paralysis of the integuments on the right side. Temporo-mandibular joint (TMJ) displacements are reduced in propulsion and diduction

Prior to his first visit, the patient had some remaining teeth (figure 8) that were extracted 5 years ago. Thus, the intraoral examination reveals totally edentulous arches with two symphysis implants (Zimmer® Length 3.7mm x 10mm). The patient wears conventional complete maxillo-mandibular removable prostheses

which are unstable when he chews hard food. Despite the severe bone resorption in both the maxilla and mandible, the vertical and horizontal prosthetic space is reduced due to the mouth opening limitation and microstomia. Tongue mobility is reduced bilaterally. Saliva quality and quantity are both normal.

Treatment decision-making

The initial treatment decision-making was for a complete fixed implant-supported prosthesis in the maxilla. Given the reduced size of the maxilla and the severe bone resorption, 5 implants were placed instead of 6, using a surgical template fabricated according to the patient's original prosthesis: 2 zygomatic implants on the left (Nobel®, Zurich-Flughafen, Suisse), respectively 47mm regarding the first molar, and 50mm regarding the canine), and 3 standard implants on the right (Nobel®, Zurich-Flughafen, Suisse), respectively 2 implants (4.3 x 10mm) regarding the first molar and the second premolar, and 1 implant (3.5 x 10mm) regarding the canine. The diverging axes were compensated using 30°-angulated multi-unit abutments (Nobel®, Zurich-Flughafen, Suisse). Implant loading was performed using the patient's initial complete removable prosthesis converted into a fixed implant-supported bridge. During the months required for osseointegration, oral hygiene maintenance revealed too difficult for the patient. When reevaluating the different clinical parameters, patient's demand and indications for different treatment options, we decided to change our initial treatment plan and to implement an implant-retained bar-supported overdenture.

In the mandible, a complete removable denture was stabilized on the 2 existing symphysis implants using axial attachments (Locator Zimmer® (Warsaw, Indiana)).

Prosthetic treatment steps

In the maxilla, accurate recording of the implant positions is required using a customized tray and a primary open-tray type I plaster impression. In the mandible, the approach is the same for a conventional complete removable prosthesis. A preliminary Type 1 plaster impression was completed by a second impression using an individual adjusted tray, thermoplastic paste border molding, and surface treatment with regular viscosity polysulphides.

The patient presented atypical facial and oral anatomical landmarks which challenged the options for VDO and occlusal plane orientation. Phonation tests were inconclusive due to the low facial and lingual muscle mobility. Despite the labial inocclusion (due to tissue sclerosis), we recorded the VDO at a height equivalent to that of the medium face stage.

The occlusal plane goes through the patient's left lip corner (non operated side) leaving the prosthetic teeth partially apparent. Then, the CB was fabricated according to the mounting of the teeth. The bar has a 2mm diameter round section, and is spaced 2 mm away from the mucosa. It was validated clinically and radiographically.

Polymerization of the CRP with the placement of brass clips

The connecting bar is screwed on the multi-unit abutments® (Nobel®, Zurich-Flughafen, Suisse) at 15 N/cm, then the CRP is clipped using the less retentive plastic components (yellow). In the mandible, the female parts of the Locators® (Zimmer, Warsaw, Indiana) are placed using the direct technique. In this instance, this option allows to limit the prosthetic maintenance (14).

CLINICAL CASE N° 2 (figures 6-8)

A 62 year-old male patient having no general health problem. He smoked 1 pack of cigarettes per day since 30 years. The mandible presented an infiltrating squamous cell carcinoma in the anterior lingual floor which had to be surgically treated with anterior hemiglossectomy and interrupting excision of the entire dentate mandible (while maintaining the mandibular angles). A fibula graft was planned to rebuild the mandible. The surgery and the implant-supported reconstruction were performed. Surgery and implant reconstruction were carried out immediately in order to anticipate the surgical and prosthetic rehabilitation of the patient. A fixed implant-supported prosthesis was considered for optimal arch restoration. The 3D planning allowed

a surgically-driven implant placement (CAD-CAM drilling and implant guides) for 6 intrafibular implants (Zimmer® (Warsaw, Indiana) (TSVB10, 3.5 or 4.1 x 16mm), and the positioning of the fibula graft.

Clinical examination and diagnosis

Post-surgical situation : the patient presents a totally edentulous maxillary arch opposed to a grafted arch using a fibula graft with 6 implants. Mouth opening is 25 mm between the lips without any evidence of microstomy. The TMJ movements in diduction and propulsion are limited. At the endobuccal level, we observe a mild generalized periodontitis in the maxilla with discolorations on the buccal aspects of the teeth. The vertical prosthetic space is reduced, given the mouth opening limitation and the fibula volume which is greater than that of the original mandible.

Treatment

Before the resective surgery and the reconstruction, a fixed implant-supported mandibular prosthesis had been planned. However, due to the tissue sclerosis leading to mouth opening limitation and therefore a reduced prosthetic space, we decided to select a complete implant-supported bar-retained overdenture. Implant loading was performed 10 months after surgery with the placement of healing caps 5mm high and 3.5 diameter (according to the important thickness of the new mucosa). Implementation of the prosthesis started 3 weeks after loading.

To circumvent the mouth opening limitation, a small ≪ custom-made ≫ screw driver fabricated from the conventional screw driver (Zimmer®, Warsaw, Indiana) facilitates the screwing/unscrewing procedures of the implant parts. The second impression using polyethers allows to fabricate a custom-made impression tray perforated around the transfers (HLTE3 Zimmer®, Warsaw, Indiana). A plaster index allows to validate the model obtained from this impression.

The phonation test shows little relevance to determine the VOD in this patient, due to his partial ankyloglossia following the surgery. The VOD is determined according to esthetic factors and the balance of the medium stage of the face. The occlusal plane is determined according to the patient's lower lip and corners of the mouth.

An esthetic and functional trial insertion of the mandibular prosthetic teeth mounted on wax is validated with the patient. The connecting bar and its counter-part located in the inner face of the prosthesis are machined in titanium according to the teeth arrangement. During the mouth trial insertion, the bar is adjusted and checked radiographically. Then the complete removable prosthesis is delivered, and the retention parts are placed.

DISCUSSION

The ambition to restore *ad integrum* the lost oral structures often leads us to select a fixed implant-supported option. Clinicians thus hope to restore esthetics, function and comfort for these edentulous patients. However, this vision is often unrealistic in a context of UADT cancer. The clinical conditions of the prosthetic management, the need for an easy access to oral hygiene, but also for the supervision of possible cancer recurrence on the surgically treated sites modify the prosthetic choice. Studies have shown (3) that patient satisfaction would be equivalent between patients wearing a complete implant-supported bar-retained overdenture or a fixed implant-supported prosthesis. Moreover, oral hygiene maintenance (often difficult in patients treated surgically for UADT cancers) is easier with a complete implant-supported bar-retained overdenture compared to a fixed implant supported prosthesis.

In these complex clinical situations, the limited mouth opening (LMO) restricts easy access to prostheses. Excessive retention of the clips must be avoided despite the great number of implants. Therefore, we will prefer the Dolder CB rather than the Hader CB.

The CBs were made of titanium for all our clinical cases because titanium CBs achieve better stress distribution on implants and peri-implant tissues than the cobalt-chromium CBs (13).

The main difficulty of the prosthetic rehabilitation is the vertical dimension paradox : Patient N°1 presented a severe bone resorption, and Patient N°2 had an oversized reconstruction. Initially, for both cases, we could therefore expect an increased prosthetic space ; however, given the microstomia / mouth opening limitation (and the oversized fibula in the mandible for Case N°2), the prosthetic space is reduced. Therefore, determining an esthetic and functional VOD becomes difficult. Tissue sclerosis leads to labial inocclusion at rest which can prove to be unesthetic. In Case N°2, this tissue sclerosis could have been limited if we had implemented a complete removable prosthesis immediately after the surgery. But, given the context (fibula graft/ UADT cancer), placing a prosthesis immediately after the surgery could lead to flap necrosis. The complete removable bar-retained overdenture remains a good alternative to the esthetic challenge (lip support, gummy smile) often observed in patients treated surgically for UADT cancer.

Another problem frequently encountered (15) in patients grafted with a fibula is mucosal hypertrophy around the implants. It consists of granulomatous mucous tissue which may complicate the implant-supported prosthetic rehabilitation (16). In Case N°2, we could have considered achieving a bar contacting the mucosa in order to reduce the stress on the implants and the bar. However, this option limits the access for good oral hygiene, and may aggravate peri-implant tissue proliferation which can become chronic. Grafting palatal gingiva in the concerned zones could be an alternative.

For Patient N°1, in the maxilla, we fabricated a CB spaced 1mm from the mucosa because his oral hygiene was good despite the limited mouth opening (LMO) and microstomia, but also to limit the stress on the peri-implant bone. Otherwise, we could have fabricated a complete prosthesis with full palate coverage. Indeed, Kim MJ and Hong SO showed that a prosthesis with full palate coverage provided a better stress distribution on the implants (particularly the most distal ones which receive the most of the loads), than a partial palate coverage). (18)

CONCLUSION

The implant-supported bar-retained overdenture represents provides a good option for the rehabilitation of such complex situations. Due to its retention, its stability, but also its easy oral hygiene maintenance, it provides patient satisfaction which proves to be equivalent or better than other prosthetic alternatives.

Patients who have undergone UADT cancer surgery and fibula free flap represent a real challenge for the clinician. Consequently, the prosthetic rehabilitation results in a compromise and evolving option which requires a very strict follow up to anticipate the various bone, mucosal, dental, and prosthetic complications which may occur.

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AUTHORS CONTRIBUTION

NO was involved in the study conception and design, material preparation, prosthodontic treatments of patient, and wrote most of the manuscript; BP was involved in criticizing the content of the manuscript and helped through the prosthodontics treatments; HC did the final review of the manuscript .

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	Connecting bar	**Milled bar**
Design (cross-section) *See Figure 2*	- Hader - Dolder (ovate) - Ackermann (ronde) - square - rectangular - L-shaped	- rectangular - ovate
Thickness	1 to 2 mm	$<$ 2mm
Material	- titanium - cobalt-chromium - PEEK - fiber-reinforced resin - zirconia	- titanium - cobalt-chromium - PEEK - fiber-reinforced resin - zirconia
Fabrication process	- cast - machined - milled	- machined - milled
Number of implants	2 to 6 implants	3 implants or more
Female part	Clips and retention devices (plastic or brass)	- counterbar and retention devices (plastic or brass)
Type of prosthesis	Removable prosthesis with mucosal support	Removable prosthesis without mucosal support
Mechanical behaviour	- tissue duality - rotation around the CB if 2 implants	- 0 degré of liberty - no tissue duality - behaves like a fixed implant-retained overdenture - behaves like a fixed implant-supported prosthesis

Table 1 Characteristics of the connecting bar and milled bar

Figure 1: Decision tree for implant-supported prosthesis and selection of implant number ; The minus sign in “oral hygiene” refers to an unsatisfying oral hygiene whereas the plus sign refers to a satisfying oral hygiene. The minus sign in “cost” refers to “expensive” and the plus sign refers to “affordable by the patient”.

Figure 2 : Connecting bars and their respective cross-section

Patient N° 1

Figure 3 : Ackermann connecting bar

Figure 4 : Final arrangement of the teeth mounted on wax

Figure 5 : Final VDO of the patient

Patient N° 2

Figure 6 Dolder connecting bar

Figure 7 : Final complete prosthesis over the connecting bar

Figure 8: A Panoramic of patient n°1 (A.1 initial case, A.2: connecting bar in place), B Panoramic of patient n°2 (B.1 initial case, B.2 connecting bar in place)