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Original Article

Reduction of morbidity of the revascularization surgery in the management of mandibular osteoradionecrosis by basilar edge preservation

J. Bettoni [a,b,*], J. Bouaoud [c], J. Duisit [d], S. Dakpé [a,b], M. Olivetto [a,b], B. Devauchelle [a,b]

[a] Department of Maxillo-Facial Surgery, University Hospital of Amiens, Avenue Laennec, 80000 Amiens, France
[b] EA CHIMERE, Picardie Jules Verne University, Avenue Laennec, 80000 Amiens, France
[c] Department of Maxillo-facial Surgery and Stomatology, Pitié-Salpétrière Hospital, Pierre et Marie Curie University Paris 6, Sorbonne Paris Cite University, AP–HP, 75013 Paris, France
[d] Department of Plastic and Reconstructive Surgery, Cliniques Universitaires Saint-Luc, Université catholique de Louvain, Avenue Hippocrate, 1200 Bruxelles, Belgium

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ABSTRACT

Introduction: The chronic complications of bone free-flap revascularization surgery are mainly characterized by skin fistulization of the osteosynthesis material, which sometimes leads to reactivation of the osteoradionecrotic phenomenon. The objective of the study is to evaluate the benefit of mandibular basilar edge preservation in bone reconstructive surgery in irradiated areas performed for the treatment of advanced mandibular osteoradionecrosis.
Materials and methods: A retrospective monocentric study conducted between 2003 and 2018 including all patients undergoing revascularization surgery for the treatment of advanced osteoradionecrotic lesion with respect to the basilar margin was conducted.
Results: Eight patients (7 males and 1 female, aged 50 to 63 years) who had a marginal mandibulectomy with reconstruction by bone free flap or composite free flap were included. The stability of the reconstruction (junction native mandible/bone free flap) was achieved on average by using 1.75 [range 0–4] mini plates (Medartis® Modus 2.0, Medartis AG, Basel, Switzerland). During the follow-up (30 ± 13 months) no chronic complication related to a dissociation of the osteosynthesis material or a reactivation of the osteoradionecrotic phenomenon were identified.
Conclusions: Despite the limited number of patients, it seems that the increase in the friction surface between the free flap and the native mandibular bone, linked to the preservation of the basilar edge, improves the primary stability of the reconstruction. This reduction in mechanical stress on osteosynthesis materials limits its use and reduces the rate of chronic complications of bone flap revascularization surgery in irradiated areas.

1. Introduction

First described by Régaud [1] in 1922 as "a vascular disorder following bone tissue irradiation", mandibular osteoradionecrosis (ORN) is a serious complication of head and neck oncological irradiation. Although the development of prophylactic measures and the advent of intensity modulated radiotherapy (IMRT) have reduced its incidence rate from 30% in 1968 to less than 10% today [2], the management of osteoradionecrotic lesions remains controversial. In a review of literature published in 2015, Rice et al. [3] propose to prioritize the therapeutic arsenal, ranging from long-term antibiotic therapy to radical surgery with free-flap reconstruction. The results of decades of pathophysiological reflection, we gladly cite the theories of the "3H" of Marx [4] ("Hypoxy, Hypocellularity, Hypovascularization"), the "2I" of Meyer [5] ("Irradiation, Infection"), the proposal of a vascular genesis by Bras et al. [6] ("Radiation-induced obliteration of the inferior alveolar artery") or the radio-induced fibrosis of Delanian et al. [7] ("Radiation-induced fibroatrophic process"). Rice et al. [3] recommend that conservative management (hyperbaric oxygen therapy, long term antibiotic therapy, pentoclo protocol or sequestrectomy with direct mucosal closure) should be preferred and that radical management, consisting of resection of the

* Corresponding author. Department of Maxillo-Facial Surgery, University Hospital of Amiens, Avenue Laennec, 80000 Amiens, France.
E-mail address: jeremiebettoni@gmail.com (J. Bettoni).

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pathological bone with reconstruction by microanastomosis flap, should be reserved to fracturial lesions or advanced subcanals refractory to medical treatment. D'Hauthuille et al. [8] characterized this procedure as a "revascularization surgery", considering that the supply of healthy vascularized tissue constitutes a physiological response to the devascularization of osteoradionecrotic bones.

Despite a high rate (86 and 100%) of effectiveness on the osteoradionecrotic phenomenon [9–15], reconstructive surgery in irradiated areas has the reputation of complex surgery, supported by its high complication rate between 18 and 75%. Among these complications, 7% to 57.5% are secondary to disassociation of the osteosynthesis material [10,11,13,15] complicated by cutaneous or mucosal fistulization or reactivation of the osteoradionecrotic phenomenon.

Considering as a starting hypothesis that these chronic complications are related to a lack of primary stability of the reconstruction, leading to cortico-periosteal necrosis at the necks of the osteosynthesis screws resulting in a chronic inflammatory phenomenon on irradiated tissues. We decided to adapt our reconstruction technique. The objective of this work is to evaluate the benefits of increasing the contact surfaces between the free-flap and the native bone, by preservation of the basilar edge during mandibular bone reconstruction in ORN context.

2. Material and method

From January 2003 to December 2018, we included all patients who received revascularization surgery for ORN lesions involving the mandibule below the inferior dental canal respecting the jaw basilar edge (with or without skin fistula) accessible to marginal mandibulectomy and requiring reconstruction by bone free flap to restore mandibular solidity. The feasibility of preserving jaw continuity was assessed preoperatively with radiographic exams (dental panoramic or X-Ray CT-scan); and intraoperatively by the absence of clinical osteolic involvement of the basilar edge.

Each osteoradionecrotic lesion was characterized by its topography (Urken classification [16]), the period between the end of irradiation and the revascularization surgery (months), as well as the modalities of reconstructive surgery (type of free flap, recipient vessels, modalities of microsurgical anastomoses). For each synthesis, the number and references of the material used were collected.

Revascularization surgery was considered effective in the absence of progressive continuation of the osteoradionecrotic phenomenon. Any local recurrence after a period of remission or osteoradionecrotic lesion at a distance from the first surgical site was considered as new episode of ORN.

During follow-up, acute complications occurring within the first 30 postoperative days were differentiated from chronic complications occurring more than one month after surgery.

2.1. Ethical consideration

This study was performed in accordance with the rules of the local ethical committees.

3. Results

Between 2003 and 2018, 8 patients were treated with this modified revascularization surgery, consisting in marginal man-

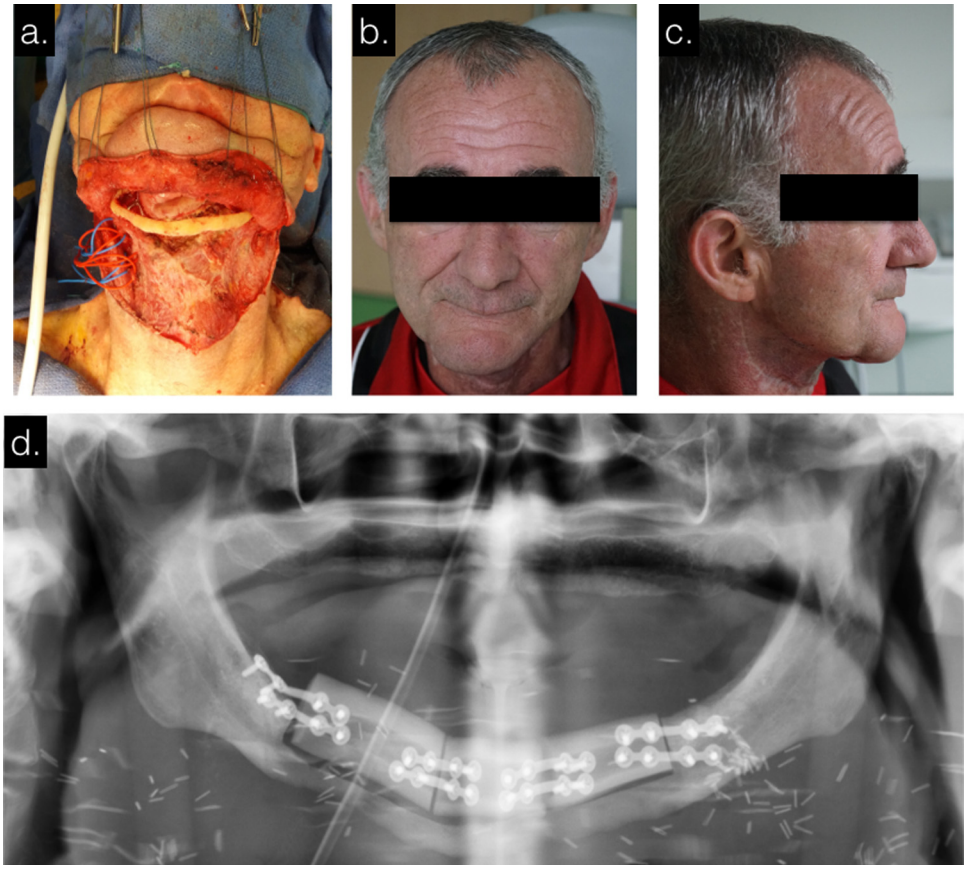

Fig. 1. (a.) Peroperative photography of a marginal piezosurgery® mandibulectomy (Mectron S.p.a, Carasco, Italy) with preservation of the basilar edge in the treatment of an ORN mandibular injury. (b–c.) 6 months postoperative photographies. (d.) Dental panoramic radiography at one week postoperatively. (Patient ID 5).

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Table 1
Characteristics of the study population.

	Revascularization surgery with preservation of the basilar edge ($n=8$)
Age (median, range)	58.5 (range 50–63)
Sex ratio (male:female)	7:1
Delays (months) between the end of irradiation and revascularization surgery (median, range)	63 (range 23–84)
Topography of osteoradionecrotic lesions[a]	
Mandibular angle	4
Mandibular body	8
Simphysis	2
Osteoradionecrotic lesions involving at least 2 Urken anatomical units	7
Skin fistula	2

[a] According to Urken's classification (s: symphisis; b: body of the mandible; r: angle of the mandible).

dibulectomy with preservation of the basilar edge (Fig. 1 and Supplementary material 1) and reconstruction by bone free flaps (7 men, 1 woman, aged between 50 and 63 years), for the management of advanced mandibular osteoradionecrotic lesions. The characteristics of this population are detailed in Table 1.

Concerning the topography of ORN, bone damage were located on the body of the mandible (8) and/or the mandibular angle (4) and/or the mandibular symphysis (2). In 3 patients, the resection of the pathological bone by piezosurgery® (Mectron S.p.a, Carasco, Italy) allowed a preservation of the lower alveolar nerve. Reconstruction for restoring the strength of the bone infrastructure involved 1 fibula free flap, 1 iliac crest free flap and 6 composite fibula free flaps with skin paddle (Table 2). Except in 1 patient (ID 3), where the strength of the construct was obtained solely by embedding the bone iliac crest free flap within the jaw resection site optimizes by suturing between the external oblique muscle and the native mucosa with absorbable suture (Ethicon Vycril® 3/0, Johnson & Johnson, New Brunswick, USA) (Fig. 2), all osteosynthesis were performed on average by 2.6 ± 1.9 miniplaques (Medartis® Modus 2.0, Medartis AG, Basel, Switzerland) (Fig. 3). Excluding the miniplates necessary for osteosynthesis of segmental osteotomies of the bone free flap, 1.75 (range 0–4) miniplaques were used on average to stabilize the assembly between native mandibular bone and bone flap.

The mean operating time for revascularization surgery was 6 h 56 ± 1 h 17 min. Regarding the microsurgery, all the anastomoses were performed in a termino-terminal fashion.

During the clinical follow-up (30 ± 13 months), we reported a post-operative cervical hematoma for 1 patient (ID 7) on post-operative day 1, requiring a revision of the anastomosis and allowing the flap to be saved, and one local infection secondary to disunion for another patient (ID 1). Nevertheless, there were no chronic complication related to the disassociation of osteosynthesis material (Table 3).

4. Discussion

In this study, we aimed to evaluate the benefits of preserving the basilar edge during mandibular bone reconstruction in an ORN context. We reported the management of height patient with an overall acute complication rate of 11.2%, and no chronic complication (dislocation of osteosynthesis material, or new episode of the osteoradionecrotic phenomenon observed).

Our study showed a lower complication rate than the others studies dealing with revascularization surgery in the treatment of mandibular ORN [9–15]. While the reduction in the rate of acute complication may be explained by early management of ORN lesions before a fracture stage, it seems that basilar edge conservation allows avoiding the occurrence of chronic complications related to osteosynthesis material (disassociation, fistulization or reactivation of the osteoradionecrotic process). Indeed, inspired by the "tenon-mortise" assembly, the significant increasing of the contact surface between the bone flap and the native bone seems to provide better primary stability for the assembly. Furthermore, the mechanical stress and tension activate osteogenesis in vitro and in vivo through inflammatory chemokines [17–19]. We think that this procedure reduces the mechanical stresses, inflammatory processes at the neck of the osteosynthesis screws and the micromovements at the origin of corticosteroperiosteal necrosis, leading to a disassociation of the material and chronic inflammation. Thus, skin fistulization and bone exposure, leading to the reactivation of the osteoradionecrotic processes, are avoided.

Table 2
Modalities for reconstructing bone loss according to each patient included.

Patient ID (sex/age)	Tumor topography	Clinical Target Volume (CTV) irradiation dose (Grays)	ORN jaw Topography[a]	Operating time	Type of free flap	Receiving artery	Vein receiving	Number of miniplaques for mandibular-free flap stability/total number of miniplaques used for the reconstruction[b]
1 (M/61)	Oropharynx	70	B	8 h 00	Fibula	Thyroid artery	Facial vein	2/2
2 (M/65)	Mobile tongue	65	B	9 h 40	Fibula + skin paddle	Thyroid artery	Internal jugular vein	2/2
3 (F/57)	Tongue base	70	B + R	6 h 22	Iliac crest	External carotid artery	External jugular vein	0/0
4 (M/50)	Mobile tongue	66	B + R	6 h 30	Fibula + skin paddle	Facial artery	Facial vein	1/1
5 (M/50)	Anterior oral floor	50	B + S + S + B	3 h 58	Fibula + skin paddle	Thyroid artery	Facial vein	4/8
6 (M/57)	Larynx	66	B + R	5 h 49	Fibula + skin paddle	Facial artery	Facial vein	2/2
7 (M/60)	Oropharynx	66	B + R	8 h 16	Fibula + skin paddle	Facial artery	Facial vein	1/1
8 (M/63)	Larynx	70	B + S + S + B	6 h 33	Fibula + skin paddle	Facial artery	Facial vein	2/5

[a] Urken classification: S-Simphysis/B-Body/R-Angle.
[b] This difference is due to the neef of two type of osteosynthesis miniplates, some are used to fix the segmental osteotomies of the bone free flap whereas the others were used to stabilize the assembly between native mandibular bone and bone flap.

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Fig. 2. Dental panoramic radiography of a revascularization surgery, at (a.) one week and (b.) one year postoperatively, involving the body of the left mandible with reconstruction by iliac crest free flap whose primary stability of the assembly was obtained without any osteosynthesis material (Patient ID 3).

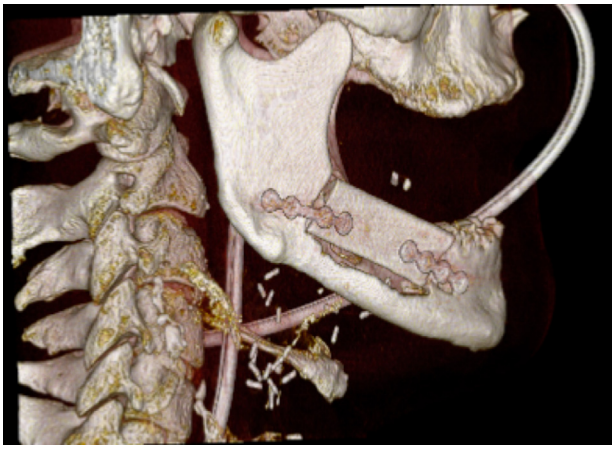

Fig. 3. 3D reconstruction of a one week post-operative CT scan of a revascularization surgery with basilar edge conservation where the increase in friction surface allows primary stability supplemented by only 2 mini osteosynthesis plates (Medartis® Modus 2.0, Medartis AG, Basel, Switzerland) (Patient ID 2).

By reducing the number of miniplates required for robust assembly, this procedure reduces the use of inert materials in an irradiated area. In addition to the economic aspects, from a technical point of view the preservation of the basilar edge makes it possible to perform mandibulectomies with preservation of the alveolar nerve diverted from its canal and spatialized into the mandibular outer table. In addition, the preservation of the native bone rail makes it possible to guide spatialization, the modalities of segmental osteotomies and to prevent the risk of condyle malposition leading to mandibular laterodeviation or limitation of the buccal opening. Finally, from an aesthetic point of view, the preservation of the basilar edge respects the oval of the face and limits subsequent asymmetries.

With only 8 cases reported in 15 years, our experience highlights the problem of early diagnosis and management of osteoradionecrotic lesions. Although it is known that the more complex the reconstruction, the higher the complication rate [20], it is still difficult to propose free-flap reconstruction in irradiated areas given the risks of acute and chronic complications (Table 3). It therefore seems essential to consider mandibular ORN as a real public health problem and to redefine an effective and documented therapeutic algorithm. Because recently the questioning of the effectiveness of the main conservative treatments by Annane et al. [21], Madrid et al. [22] or Martos-Fernandes et al. [23], requires a profound reflection on the therapeutic strategy to be adopted concerning mandibular ORN. It is therefore paradoxical that having proven its effectiveness (range 86–100%) [9–15], revascularization surgery is not only considered as a treatment of recourse. Some authors [24,25] propose to extend its indications immediately after the failure of conservative treatments. Considering the refractoriness of medical treatments as a gravity criterion in its own right, requires a modification of the therapeutic strategy. In 2009, D'Hauthuille et al. [25] proposed the use of the periosteal flap in the event of refractory superficial damage during sequestrectomy and direct closure. This attitude based on the osteoinductive [26] and neoangiogenic [27] potential of periosteal flaps makes it possible to offer effective early treatment of osteoradionecrotic phenomena. But above all, this therapeutic sequence is part of a revolution that reserves effective therapy only in the event of an outdated or fractured lesion where the complexity of the reconstruction exposes the patient to a high complication rate [20]. If the objective of mandibular ORN management is to stop the osteoradionecrotic phenomenon by controlling complications, it seems essential to identify ORNs refractory to concerted treatment and to propose early revascularization surgery in a multicentric study to provide a sufficient level of evidence to load the current paradigm.

The basilar margin preservation offers the prospect of a reduction in chronic complications and aesthetic sequelae associated with bone reconstruction. Nevertheless, this attitude requires close collaboration between the various actors (radiotherapists, dentists, general practitioners and surgeons) allowing early diagnosis and effective and appropriate graduated management. Moreover, given its technical constraints, mandibular ORN surgery should be centralized in expert centers because any failure penalizes the success of subsequent interventions exposing to real therapeutic impasses.

Table 3
Literature review of acute and chronic complications in series of patients managed for mandibular osteoradionecrosis.

	Gal et al. [10] ($n=30$)	Suh et al. [11] ($n=40$)	Baumann et al. [13] ($n=63$)	Cannady et al. [14] ($n=53$)	Bettoni et al. [15] ($n=119$)	Our study ($n=8$)
Acute complication rate	10%	17,5%	21%	24%	31%	11,2%
Total necrosis of the free flap	nk	nk	3	7	12	0
Partial necrosis of the free flap	0	0	0	1	10	0
Hematoma	2	0	3	0	1	1
Local infection	0	7	7	0	2	1
Other	1	0	0	5	10	0
Chronic complication rate related to osteosynthesis miniplates	33%	57,5%	7%	nk	18%	0 %
Overall complication rate	43%	75%	28%	24%	49%	11,2%

nk: not known.

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5. Conclusion

Given its complexity, revascularization surgery must be conceptualized as a unique and curative procedure that restores or preserves the solidity of the mandibular infrastructure and bone sealing essential for oral health. Our study is in favour of preserving the basilar edge where it is possible. This procedure seems to offer a better primary stability during assembly, allowing a reduction in both stress on the osteosynthesis equipment and the resulting chronic complications (fistula and/or reactivation of the osteoradionecrotic phenomenon). But this preliminary results have to be confirmed with more cases or by studies with higher level of evidence.

Disclosure of interest

The authors declare that they have no competing interest.

Appendix A. Supplementary data

Supplementary data (X-ray CT scan 3D reconstruction at 1 year postoperative [ID 5]) associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jormas.2019.08.007.

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