PLASTIC RECONSTRUCTIVE & REGENERATIVE SURGERY
2024;1:17-25
DOI: 10.57604/PRRS-446

MANDIBULAR RECONSTRUCTION USING A FREE FIBULA FLAP IN A DISADVANTAGED ENVIRONMENT

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Summary
Mandibular reconstruction remains a real challenge for the maxillofacial surgeon. Reconstruction techniques have evolved considerably and currently the gold standard is the fibula free flap (LLF).
In sub-Saharan Africa, this intervention is rarely practiced due to lack of human resources (few specialist practitioners practicing this type of intervention) and technical resources (equipment, under-medicalization of the population, difficult and expensive access to care).
Furthermore, in low- and middle-income countries, certain maxillofacial pathologies are specific, such as giant mandibular ameloblastomas, benign tumors characterized by an often impressive volume responsible for facial deformities and functional impotence, in patients with poor oral hygiene.
Surgical management of such tumors requires mandibular reconstruction to meet functional and aesthetic requirements.
It is in this context that collaborative missions between the maxillofacial surgery services of the Pitié-Salpêtrière University Hospital Center (CHU) (Sorbonne University, Paris, France) and the Aristide le Dantec University Hospital (Dakar, Senegal) have been initiated since 2016. The objective of these missions is to allow patients from Senegal and the West African sub-region to benefit from mandibular reconstructions by LLF in Dakar (Senegal).

Key words: free fibula flap, giant mandibular ameloblastoma, collaborative mission, humanitarian, disadvantaged environment, microsurgery

Received: February 13, 20234
Accepted: April 5, 2024

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How to cite this article: Ndiaye MM, Bouaoud J, Touré S, et al. Mandibular reconstruction using a free fibula flap in a disadvantaged environment. PRRS 2024;1:17-25. https://doi.org/10.57604/PRRS-446

INTRODUCTION

Mandibular reconstruction constitutes one of the major difficulties of head and neck reconstructive surgery. The goal of this reconstruction is to restore bone continuity in order to restore mandibular function and aesthetics, all of which guarantee an acceptable quality of life for patients [1-3].
The evolution of surgical techniques, in particular the advent of free composite transfers, has made it possible to improve the quality of mandibular reconstructions after excision surgery. In particular, fibular free flap is in fact the gold standard in cases of interruptive mandibulectomy [4].

This flap was first described by Taylor in 1975, it was then used for reconstruction of the lower limb [5]. It was in 1989 that this flap was transferred for the first time to the cervico-facial region by Hidalgo to reconstruct the mandible [6].
In low- and middle-income countries, such as some in Africa, this intervention is rarely performed, which constitutes a loss of opportunity for patients. Indeed, few practitioners are familiar with this type of reconstruction and carrying out this type of intervention requires technical mastery and optimal perioperative management.
Furthermore, maxillofacial surgery is a specialty that is not very widespread in Africa and suffers from a lack of human resources (specialist practitioners) and equipment [7].
Access to specialized, adapted surgical care is therefore limited. This is an element which contributes, at least in part, to the delay in patient care (Fig. 1).
Finally, certain maxillofacial pathologies encountered in Africa are specific, such as giant mandibular ameloblastomas, a benign tumor characterized by its often impressive volume responsible for facial deformities and functional impotence, in patients with poor oral hygiene [8].
It is in this context that collaborative missions between the maxillofacial surgery services of the Pitié-Salpêtrière University Hospital Center (CHU) (Sorbonne University, Paris, France) and the Aristide le Dantec University Hospital (Dakar, Senegal) have been initiated since 2016 [9].
The objective of these missions is to allow patients from Senegal and the West African sub-region to benefit from mandibular reconstructions by LLF in Dakar (Senegal).
We report here our experience and our results of mandibular reconstruction using LLF through 3 cases.

SURGICAL TECHNIQUE

The surgical procedure takes place in two teams (made up of different surgeons from the two university hospitals), one carrying out the tumor excision (Figs. 2A-B) while the other ensures the simultaneous removal of the LLF (Figs. 2C-F). The anesthesia team is exclusively composed of local anesthesiologists trained in Senegal. The limits of the mandibular bone resection are determined based on the preoperative imaging assessment. The vascularization of the future LLF is checked preoperatively by palpation of the distal pulses (pedial, anterior and posterior tibialis). The LLF is taken, with or without a pneumatic tourniquet, most often from the side opposite the interruptive mandibulectomy on the contralateral side in order to facilitate the placement of the skin paddle in the mouth.
The important landmarks (head of the fibula, external malleolus, lateral intermuscular septum) as well as the future septocutaneous palette are drawn. The skin paddle is thus taken from the union of the middle and lower thirds of the leg, since this is the region where the septocutaneous perforators are most likely to be present. The size of the septocutaneous paddle is adapted to the loss of substance to be reconstructed (up to 5 x 11 cm). The skin incision is made 1 cm behind a line joining the head of the fibula proximally to the external malleolus distally while respecting the anterior edge of the future cutaneous paddle of the LLF. The anterior edge of the skin paddle is tilted with its septum in order to visualize and preserve the septocutaneous perforators. Stitches can also be made between the anterior septum and the skin paddle in order to avoid any shearing of the perforators. The dissection continues through the peroneus longus muscles (antero-external compartment) until reaching the antero-external edge of the fibula. Thus a thin muscular layer approximately 1 mm thick covers the fibular bone. The anterior inter-muscular septum separating the antero-external and anterior compartments

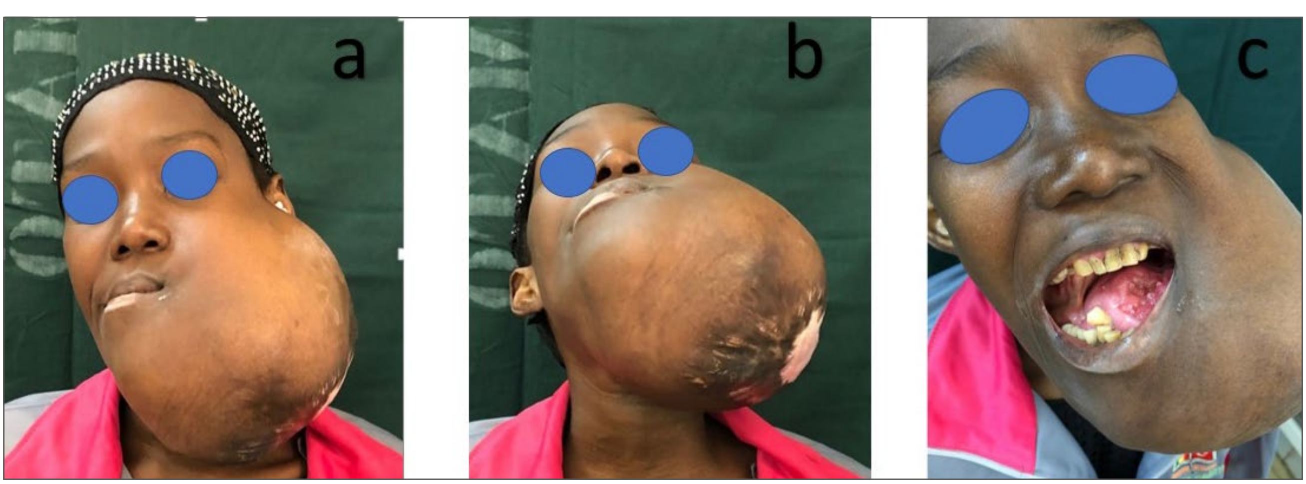

Figure 1. Large left mandibular ameloblastoma showing delays in specialized treatment (Case 1).

is open. The dissection continues through the extensor digitorum longus muscles until reaching the interosseous membrane, while taking care to tilt the pedicles and anterior tibial nerve. The antero-external and anterior face of the fibula is thus released. The osteotomies are then carried out with an oscillating saw or, failing that, a Gigli saw, respecting 7 cm of fibula proximally so as not to damage the external popliteal sciatic nerve and 7 cm distally to preserve the stability of the ankle.

Once the osteotomies have been performed, the section of the interosseous membrane is carried out over its entire height. The fibular pedicle is located distally and ligated. The posterior tibial muscle located above the pedicle can be divided, taking care to preserve the fibular pedicle. The section of the posterior edge of the skin paddle is carried out taking care to preserve the septocutaneous perforators previously identified. Stitches can also be made between the posterior septum and the skin paddle to avoid any shearing of the perforators.

The dissection continues through the posterior compartment of the leg by retracting the soleus muscle, the proximal perforators of which must be ligated (unless a double-paddle LLF is removed). Finally, the flap and its feeding pedicle are released medially by cutting the intermuscular septum. The sampling continues with the dissection of the fibular pedicle proximally until its birth (bifurcation also giving rise to the posterior tibial pedicle) in order to have the maximum pedicle length for the creation of the micro-anastomoses (Fig. 2C). Future release of the fibular pedicle will only be carried out downstream of this bifurcation. Throughout the collection, it is important to take care to clip/ligate the muscular perforators and to achieve hemostasis gradually in order to avoid any massive blood loss. If the sample was taken under a tourniquet, the latter can be lifted in order to limit the time of vascular hypoperfusion.

The LLF is then shaped on site and left in a nurse until its cervical transfer in order to limit ischemia time (Fig. 2D). Once the recipient cervical vessels are ready, the flap is released by ligation of the fibular pedicle (flap ischemia). After a brief rinsing of the flap with heparinized serum and fixation of the flap with a mini titanium osteosynthesis plate, the vascular micro-anastomoses are most often performed on the same side as the mandibular excision (Figs. 2E-F). These most often involve end-to-end anastomoses between the fibular artery and one of the branches of the external carotid artery (facial or lingual artery) as well as between a vein and a major collateral of the internal jugular vein (facial or lingual

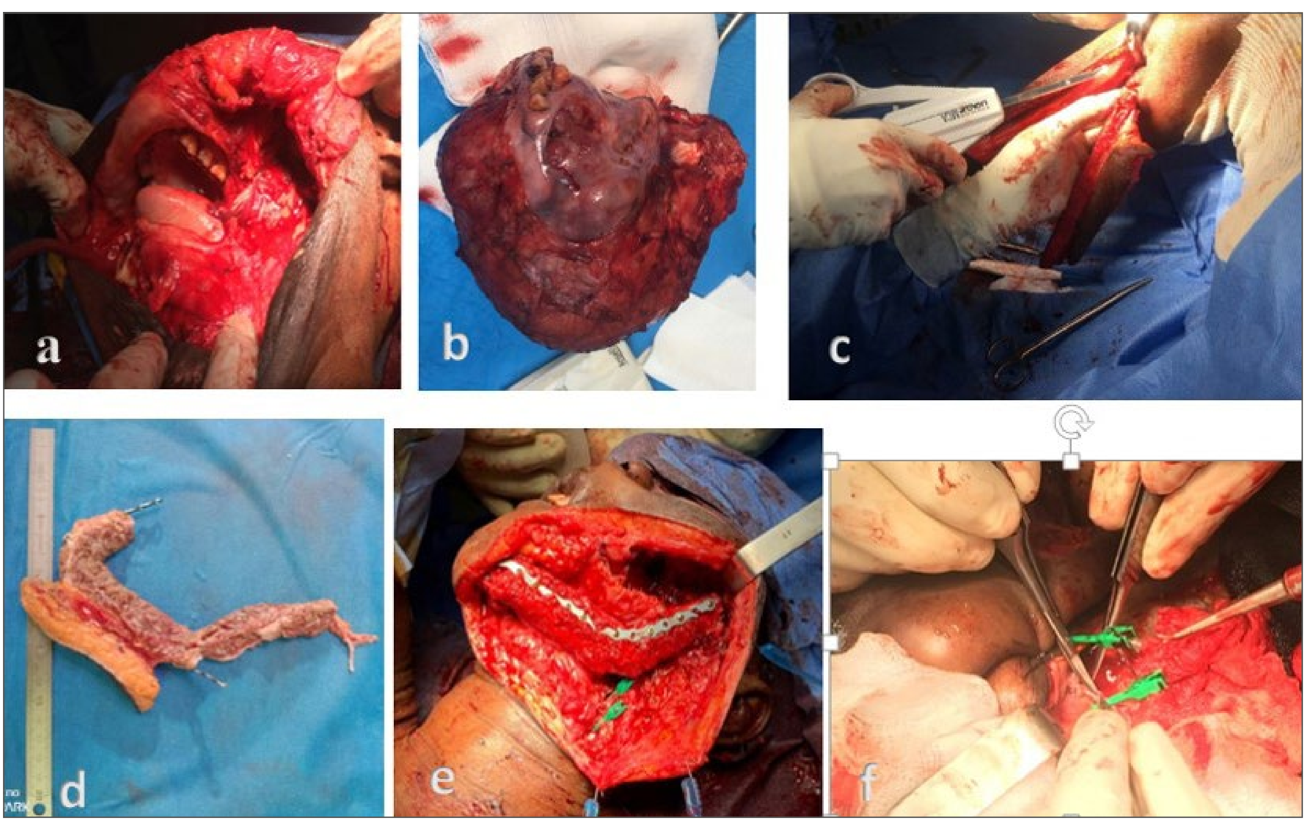

Figure 2. Left interrupter mandibulectomy + LLF reconstruction (Case 1).

vein) or the external jugular vein. The permeability of the anastomoses is checked using the permeability test (Patency test) as well as the good viability of the skin paddle (Figs. 3A-B).
After checking washing and hemostasis, the LLF sampling site is closed.
A suction drainage system is left in place to prevent the risk of hematoma of the compartments. The loss of skin substance linked to the removal of the skin paddle is filled by a full-thickness skin graft taken from the inguinal region. A posterior cast splint is made at the end of the procedure, for analgesic purposes and to stabilize the skin graft, and left in place for three to five days. An imaging check is carried out as soon as possible post-operatively (Fig. 3C).
All patients receive drug prevention for deep vein thrombosis (heparin at a preventive dose from day 1 to day 5 post-operatively).
The median length of hospitalization was 28 days. Patients are seen again at 6 months and 1 year post-operatively.

COHORT

Through 3 clinical cases we present the clinical forms most frequently encountered in our practice: i) primary reconstruction post excision of primary or ii) recurrent giant ameloblastomas of the mandible and iii) secondary reconstructions after interruptive mandibulectomy performed several years ago.

Figure 3. Post-operative results (Case 1).

CASE 1: PRIMARY POST-EXCISION RECONSTRUCTION OF A PRIMARY GIANT AMELOBLASTOMA OF THE MANDIBLE

This is a 21-year-old patient, with no notable pathological history, admitted for the treatment of a large mandibular tumor that had been evolving for seven years, long neglected by the patient.

On examination, the patient was in good general condition. The exo-oral examination revealed a large non-inflammatory swelling of the left lateral-mandibular region, painless, measuring 21 cm in its long axis, of variable consistency (sometimes renitent, sometimes hard), attached to the deep and superficial planes, occupying a important part of the face and oral cavity, preventing the mouth from closing. The skin opposite bore the scars from the iterative gestures of local traditional therapists (scarifications) (Figs. 1A-B). There was no cervical lymphadenopathy or cranial nerve involvement.

The intraoral examination showed very significant tumor expansion, with bulging of the floor of the mouth covered with ulcerated mucosa in places and dislocated or displaced teeth (Fig. 1C). There was no limitation of mouth opening.

The CT scan revealed a large heterogeneous left mandibular tumor, polycystic, septate, with swelling of the cortices which were lysed in places; there were no signs of malignancy. The diagnosis of ameloblastoma was strongly suspected.

The surgical procedure consisted of a left interrupter mandibulectomy extending from the left mandibular branch to the right mandibular angle via the intraoral and cervical route with immediate reconstruction using LLF taken from the left (Fig. 2). The pathological study confirmed the diagnosis of ameloblastoma, with healthy excision limits.

The post-operative course was simple: early rise, enteral feeding via nasogastric tube for a week then oral transfer and discharge on the tenth post-operative day. At one month post-operatively, the functional and aesthetic results were satisfactory (Fig. 3).

CASE 2: PRIMARY POST-EXCISION RECONSTRUCTION OF A RECURRENT GIANT AMELOBLASTOMA OF THE MANDIBLE

This is a 48-year-old patient referred for treatment of a right mandibular tumor that has been evolving for 7 years. Two mandibular curettages had been carried out 3 years and 5 years previously. The pathological analyzes were all in favor of an ameloblastoma.

On examination, the patient was in good general condition. Exo-oral examination revealed swelling extending from the right mandibular angle to the left mandibular body (Fig. 4). The swelling was polylobed, painless, of mixed consistency (tissue and fluid) and caused facial asymmetry without swallowing problems or dyspnea. There was no skin ulceration. Cervical examination did not find any lymphadenopathy.

The intraoral examination revealed a mass extending over the entire toothed portion of the right hemi-mandible, half of the left mandibular body up to the second premolar. This swelling bulged the floor of the mouth and pushed the tongue to the left. There was no limitation of mouth opening or mucosal ulceration.

The scan carried out revealed a large mandibular tumor (12 x 8 x 5 cm), heterogeneous, polycystic, septate with cortical bone lysis, without signs of malignancy.

The surgical procedure consisted of an interruptive mandibulectomy via the intraoral and cervical route with immediate reconstruction using LLF taken from the left. The pathological examination was in favor of a mixed ameloblastoma, follicular and plexiform, completely excised.

The post-operative course was simple: early rise, enteral feeding via nasogastric tube for a week then oral transfer and discharge on the tenth post-operative day. At one year post-operatively, the functional and aesthetic results were satisfactory (Fig. 5).

CASE 3: SECONDARY RECONSTRUCTION AFTER INTERRUPTIVE MANDIBULECTOMY

A 24-year-old female patient was referred for secondary

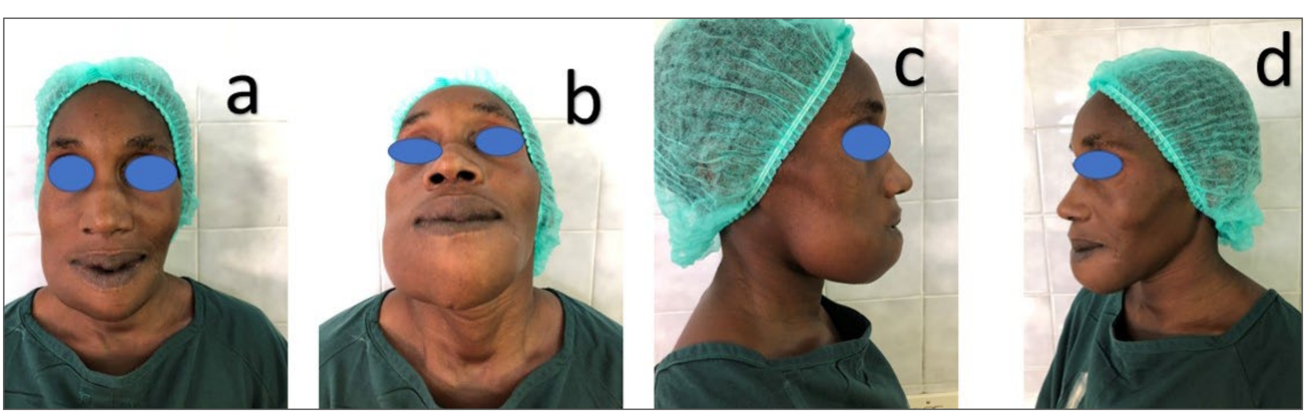

Figure 4. Right mandibular ameloblastoma (Case 2).

Figure 5. Morphological and functional results after mandibular reconstruction using a free fibula flap (Case 2).

mandibular reconstruction one year after a left side-terminal interruptive mandibulectomy performed at the time for excision of a giant mandibular ameloblastoma. On examination, the patient was in good general condition. Exo-oral examination revealed facial asymmetry and disappearance of left basilar and angular bone relief (Fig. 6). There was also a left cervical cutaneous flange related to the cervical mandibulectomy approach.

The intraoral examination did not reveal any limitation of the mouth opening but one due to right mandibular lateral deviation (healthy side) at the mouth opening. The mucosa of the lingual floor was continuous with the jugal mucosa (absence of vestibule).

The radiological analysis revealed a loss of substance of 43 in the left mandibular condyle.

The indication for secondary mandibular reconstruction using LLF was made. The procedure took place under general anesthesia. The LLF was harvested on the right and conformation with three intermediate osteotomies was performed. After osteosynthesis and microsurgical anastomosis, the different surgical sites were closed. The post-operative course was simple (comparable with that of Case 1). At one year post-operatively, the functional and aesthetic results were satisfactory (Fig. 7).

DISCUSSION

The management of maxillofacial pathologies poses a real problem in low- and middle-income countries due to lack of human resources (specialist practitioners proficient in this type of technique) and financial resources (osteosynthesis equipment, etc.).

In fact, unlike developed countries, where mandibular tumors are diagnosed at the asymptomatic stage or discovered incidentally, in low- and middle-income countries mandibular tumors are seen in the majority of cases in giant forms. These giant forms are partly linked to a delay in treatment due to the low socio-economic level of patients, their mythical considerations, lack of knowledge of this type of pathology (no awareness of the population regarding this pathology), under-medicalization and finally difficult and expensive access to care [10]. On the other hand, these giant ameloblastomas also reflect the negligence of patients (slow and painless development) and the influence of traditional therapists, the first contacts of patients offering them inappropriate treatments. The time taken to treat mandibular tumors varied from 1 to 10 years depending on the series in Africa [8,10,11]. Finally, certain factors, particularly environmental (diet, lack of hygiene, etc.) can be mentioned

Figure 6. Loss of left mandibular substance after non-reconstructed mandibulectomy (Case 3).

Figure 7. Morphological and functional results after mandibular reconstruction using a free fibula flap (Case 3).

due to the particularly high frequency of giant ameloblastomas in Africa.

Giant forms of mandibular ameloblastoma constitute a major therapeutic problem because they require complete resection of the affected mandible, compromising the functional and aesthetic prognosis [12]. Thus these large losses of substance of the lower third of the face common in our practices, are characterized by the importance of the volumes concerned, their composite character affecting different tissues (bone, mucosa, skin, muscle, tooth) and the three-dimensional imperative of their reconstruction after their excision. In Africa, the surgical management of these giant mandibular tumors faces three pitfalls: i) the lack of osteosynthesis and maxillofacial reconstruction materials; ii) the technical limits of practitioners, due to lack of specific training in this regard. with maxillofacial reconstructive surgery and iii) under-medicalization and difficult and expensive access to care.

This explains why today in Africa most mandibulectomies are not reconstructed. Mandibular reconstruction techniques have evolved significantly in recent years (metal endoprostheses, non-vascularized bone grafts, etc.) [13]. Free vascularized bone transfers today represent the technique of choice [4]. LLF and free iliac crest or scapula flaps are among the main options [14].

In the literature, the only studies found in sub-Saharan Africa on free flaps were carried out in Nigeria with limited series [15,16]. No studies were found in French-speaking sub-Saharan Africa.

A meta-analysis by Lonie et al., on a selection of 28 articles from 1960 to 2014, compared LLFs to free iliac crest flaps for the reconstruction of mandibular defects. The results suggest that the iliac crest is the donor site of choice for reconstructing bone loss limited to the mandibular angle, whereas LLF is the gold standard for restoring significant mandibular bone loss, subtotal, total or greater than 8 cm [17]. Indeed, the length of fibular bone removed can extend up to 25 cm and allow the reconstruction of almost the entire mandible [18].

The reliability of the LLF is currently widely recognized [19]. The rich periosteal vascularization of this flap allows the performance of multiple osteotomies to best reproduce the mandibular contours. A large skin paddle can be reliably integrated into this flap, to reconstruct an associated mucosal or cutaneous defect. The skin paddle associated with the fibula flap is thinner and more moldable than that associated with the iliac crest or scapula flap, this is particularly valuable for the reconstruction of the mucosa of the oral cavity. Indeed, this skin paddle has the ideal qualities to replace the oral mucosa and thus avoid lingual fixation in scar tissue (ankyloglossia) [20]. This guarantees optimal results for swallowing, speech and phonation.

The distance between the LLF harvesting site and the cervico-facial region allows simultaneous work in double teams (mandibular excision and harvesting of the LLF). Furthermore, osseointegrated dental implants can be placed reliably in this flap, at the same time as the mandibular reconstruction or in a delayed manner [21].

The fibula flap has the advantage of providing a long vascular pedicle (12 to 15 cm using the distal portion of the fibula) and of good caliber. If necessary, this allows micro-anastomoses to be carried out on the contralateral vessels [18].

LLF can also be used after enlarged mandibulectomy or pelvi-mandibulectomy in cases of malignant tumors [22].

Vascular failure rates of LLF vary between 5 and 15% [17,23]. Certain antecedents (cervical lymph node dissection, radiotherapy, chronic smoking) are conducive to atherosclerosis, in particular obliterating arteriopathy of the lower limbs. This is why a Doppler ultrasound and/or CT angiography of the vessels of the lower limbs must be systematically performed pre-operatively [24]. In our series, due to technical and economic constraints, no imaging of the lower limbs was performed. However, the search for anterior and posterior peripheral tibial pulses and the pedal pulse was systematically carried out pre-operatively.

Furthermore, despite technical progress, this surgery exposes people to complications such as scar disunity, infection, orostoma, donor site morbidity, functional after-effects (occlusal disorder, etc.) and/or aesthetic (facial asymmetry, etc.), resulting for the patient in multiple surgical revisions and prolonged hospitalizations. The low number of patients reported here explains the absence of complications observed.
Overall, the morphological and functional results of the patients reported were satisfactory. The experience acquired during collaborative missions organized twice a year that began in 2016 makes it possible to familiarize local teams with mandibular reconstruction using LLF and also to potentially limit the complications that arise from it.
The main objective of the collaborative missions was to allow patients from Senegal and the West African sub-region to be operated on in Dakar for serious pathologies which would normally have required medical evacuation to the West. This type of medical evacuation is difficult to organize on a social, technical and financial level. The missions therefore respond to all of these challenges by maintaining quality care.
In the short term, the mission aims to help as many patients as possible benefit from this type of surgery. In the medium and long term, the objective is to allow local teams to be autonomous and thus be able to carry out these types of interventions outside of any mission. Teaching medical and paramedical personnel must be a major focus of these missions, for the transfer of skills in order to perpetuate this type of specialized care in the host country [25].

CONCLUSIONS

The fibular free flap is the gold standard technique for mandibular reconstruction worldwide. We were able to perform this mandibular reconstruction technique in Senegal with good morphological and functional results in limited conditions.
Faced with the lack of skills and specialized centers in maxillofacial surgery, the organization of collaborative missions makes it possible to compensate for these gaps while participating in the development of this type of technique in sub-Saharan Africa. The success of these missions and their evaluation should enable the development of sustainable training and upgrading programs for young African surgeons to acquire the necessary skills.

Conflict of interest statement
The authors declare no conflict of interest.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contributions
MMN: A, D, S and W
JB: A, S and W
ST: O (coordinator)
MB: DT AC: O (coordinator)
CB: O (coordinator)
PG: O (coordinator)
All authors participated in the design, acquisition, analysis and interpretation of the data, as well as in drafting the article or revising it critically for its important intellectual content. All authors approved the final version to be published.

Abbreviations

A: conceived and designed the analysis
D: collected the data
DT: contributed data or analysis tool
S: performed the analysis
W: wrote the paper
O: other contribution (specify contribution in more detail)

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