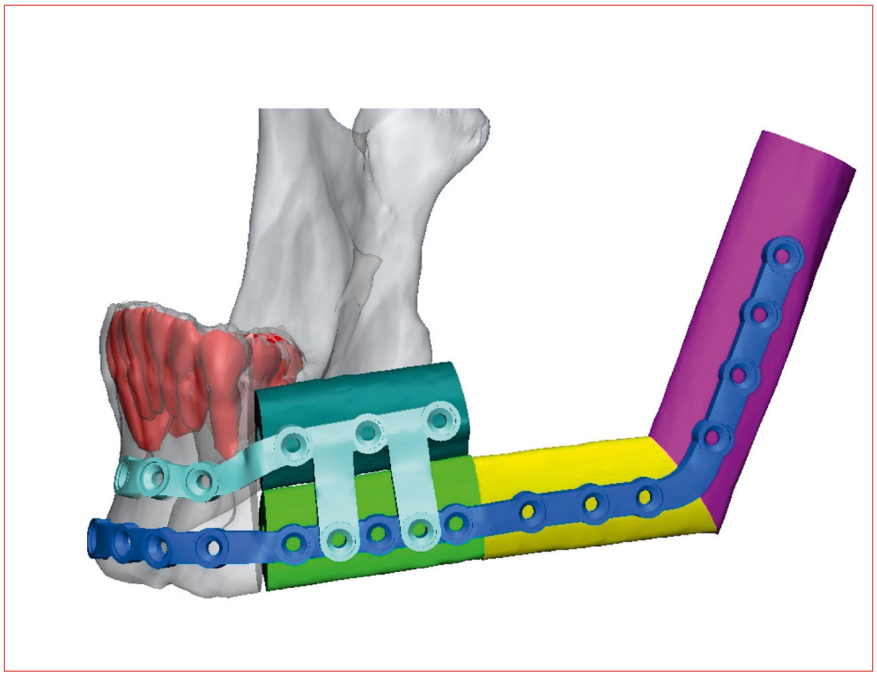
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Review of fixation techniques in double-barrel fibula flap and introduction of a new technique



Cover figure. EASY-WEAR-OFF CAD/CAM patient-specific implant, double-barrel double-plate

Resi Pucci[1], Carola Grazia Corbetta[1,2], Michele Di Cosola[3], Vincenzo Antonio Marcelli[1], Flavio Andrea Govoni[1], Nicola Felici[4], Roberto Pistilli[1]

[1] Department of Head and Neck, San Camillo-Forlanini Hospital, Rome, Italy; [2] Department of Oral and Maxillofacial Sciences, La Sapienza University of Rome, Rome, Italy; [3] Department of Clinical and Experimental Medicine, University of Foggia, Foggia, Italy; [4] Unit of Plastic, Reconstructive and Hand Surgery, San Camillo-Forlanini Hospital, Rome, Italy

Summary

Objective. The fibula flap is the preferred choice for mandibular reconstruction, especially with recent technological advancements. This study presents and evaluates a novel EASY-WEAR-OFF CAD/CAM patient-specific implant (PSI) double-barrel double-plate designed to improve stabilisation and outcomes.

Methods. A custom CAD/CAM plate with 2 parts, a long-bar and a short-bar plate, connected by vertical rods, was developed. Implant placement was performed under local anaesthesia alongside the removal of the short-bar plate at 6 months postoperatively. Literature on fixation techniques and CAD/CAM designs was reviewed to contextualise this approach.

Results. The double-barrel technique provides greater vertical bone height than the single-bar, reducing the bone gap and improving implant conditions. This PSI shows potential for better patient satisfaction and functional outcomes, supporting easier implant placement and postoperative management.

Conclusions. This CAD/CAM PSI may enhance mandibular reconstruction using the double-barrel fibula flap. Further studies with larger cohorts are needed to confirm its clinical benefits and long-term outcomes.

Key words: double-barrel fibula flap, mandibular reconstruction, implant rehabilitation, CAD/CAM, ameloblastoma

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Correspondence
Carola Grazia Corbetta
E-mail: carolagrazia.corbetta@uniroma1.it

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Introduction

Taylor and Tamai first described the free fibula flap in 1975 [1], and it has since been widely used for the reconstruction of both the mandible and maxilla. The primary objective of this procedure is to restore the continuity and anatomical integrity of the affected region while improving essential functions such as swallowing, mastication, and speech. The ability to place dental implants is a critical aspect of functional rehabilitation. The fibula flap is considered a reliable and consistent bone flap, enabling predictable outcomes in implant rehabilitation [2]. However, the fibula flap's vertical height is often insufficient to match that of the native mandible, potentially complicating dental rehabilitation. This limitation can be addressed by employing the double-barrel technique, which offers several advantages over the single-bar approach. It reduces the bone gap between the flap and the residual mandible while increasing vertical bone height, thereby creating more favourable conditions for subsequent implant placement [3]. The fibula segment available for mandibular reconstruction can extend up to 15 cm [4]. In recent years, virtual surgical planning (VSP) has become increasingly prominent due to advances in digital technology. Modabber et al. were among the first to compare conventional surgery with computer-assisted mandibular reconstruction using free fibula flaps. They highlighted the critical role of preoperative planning, and the use of surgical guides has been shown to reduce ischemic and shaping times, positively influencing surgical outcomes and flap viability. VSP primarily refers to the digital preoperative planning process, including 3D imaging, virtual osteotomies, and the design of patient-specific surgical guides. In contrast, Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) involves the actual fabrication of custom-made prostheses or implants, such as reconstruction plates, based on VSP data.

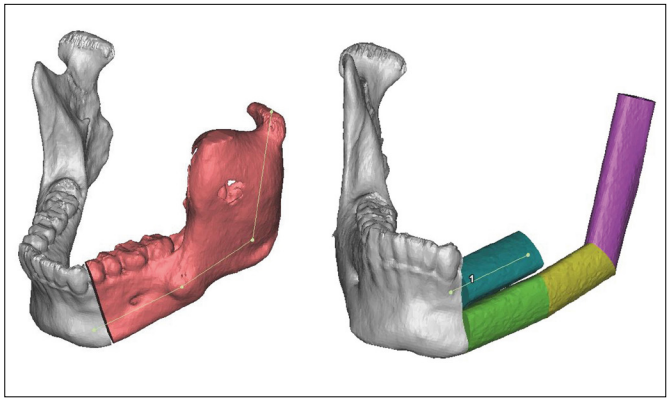


Figure 1. VSP of mandible resection and reconstruction.

As an alternative to CAD/CAM plates, conventional titanium plates can be used. These are manually contoured intraoperatively and fixed to the remaining bony stumps. To ensure flap stability, both the upper and lower barrel must be securely fixed to the mandibular stumps using titanium reconstruction plates, mini-plates with mini-screws, long screws, or a combination of these fixation methods. The choice of fixation plates in the double-barrel technique depends on several factors, including defect size, functional requirements, and the surgeon's preferences.

CAD/CAM patient-specific plates represent a significant advancement by offering superior anatomical fit and precision. Nevertheless, standard reconstruction techniques remain a valid option, especially in clinical settings with limited access to digital technologies, or in advanced oncologic cases where surgery cannot be delayed accommodating the fabrication of a CAD-CAM prosthesis.

Clinical case

A 27-year-old male presented with an osteolytic lesion affecting the left mandible. The clinical picture was advanced, featuring cortical bone erosion, root resorption of adjacent teeth, and restricted mouth opening. A biopsy confirmed the diagnosis of an aggressive multicystic acanthomatous ameloblastoma, affecting the region from the left mandibular second molar to the entire ascending ramus, including abnormal remodelling of the left condyle. Given the extensive size of the lesion and the complete cortical erosion at multiple sites on both the buccal and lingual aspects, resective surgery was deemed the most appropriate treatment approach [5]. A CT scan of the head and neck, along with a CT angiography of the lower limbs, was performed to assess the anatomy and vascular supply for potential fibular flap harvesting. Due to vascular anomalies of the right leg, a peroneal artery dominance associated with hypoplasia of the anterior tibial artery, it was decided to harvest the fibula flap from the left leg. VSP (Fig. 1) was performed to design a custom EASY-WEAR-OFF CAD/CAM PSI double-barrel double-plate fibula flap (Corios Network®). The patient underwent a segmental mandibulectomy with the assistance of custom-made cutting guides, followed by immediate mandibular reconstruction using the PSI double-barrel fibula flap (Cover figure and Figure 1). The flap showed no signs of vascular compromise. Six months postoperatively, the upper plate was removed under local anaesthe-

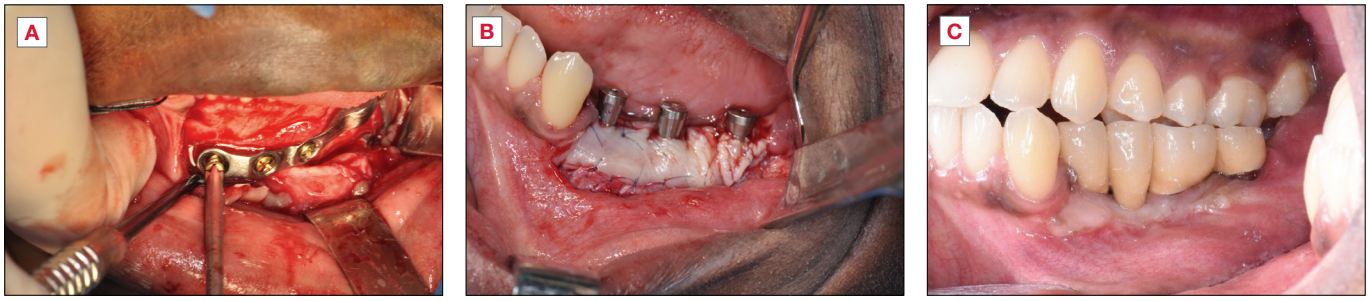


Figure 2. **A)** Removal of the upper plate; **B)** Free skin graft and implants loaded; **C)** Final prothesis.

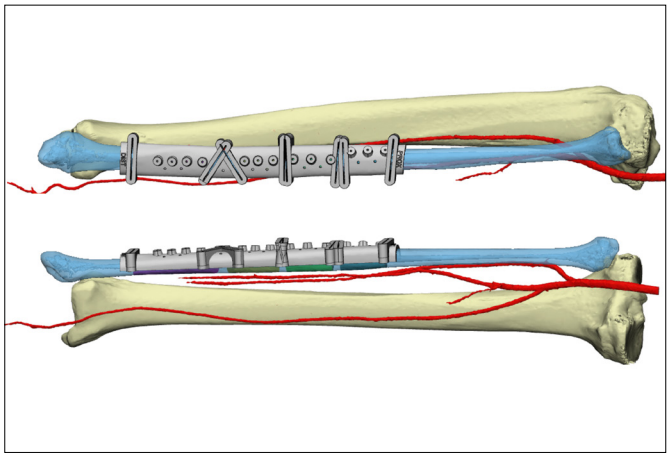


Figure 3. Fibular flap showing the CAD/CAM designed cutting guide and planned osteotomy segments.

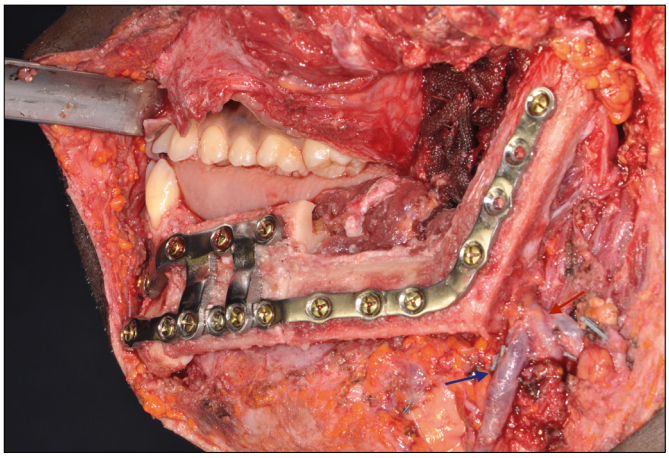


Figure 4. Free fibular flap fixated on the mandible; on the right the artery (red arrow) and vein (blue arrow) are visible.

sia (Fig. 2A), and dental implants (GlobalD®) were placed during the same procedure. Three months later, a free skin graft harvested from the clavicular region was used to generate a continuous band of keratinised mucosa around the implants. The implants were then loaded during the same procedure (Fig. 2B). Following complete mucosal healing, the definitive prosthesis was delivered (Fig. 2C). No early or late complications were observed during the follow-up period. This strategy was particularly suitable considering the patient's young age and the absence of any indication for adjuvant radiotherapy.

Results

The EASY-WEAR-OFF CAD/CAM PSI double-barrel double-plate consists of a lower long-barrel reconstruction plate, which incorporates 3 fibula flap segments, and an upper short-barrel plate, which incorporates one segment (Fig. 1, Cover figure). The segment on the upper plate is the most proximal (Fig. 3). The pedicle was anastomosed end-to-end to the facial artery, 1 cm from the external carotid artery, and the 2 veins were anastomosed end-to-end to 2 vessels from the thyrolingual trunk (Fig. 4). The lower plate comprises 2 horizontal segments, along with a vertical segment attached at an obtuse angle. This obtuse angle mirrors that of the original mandible, defined by a horizontal line extending from the body of the mandible to a vertical line at the centre of the condylar head. The most distal fibular segment functioned as a neocondyle and was positioned in direct contact with the articular disc, which was preserved in situ. This design allowed the reconstructed mandibular ramus-condyle unit to replicate the patient's original mandibular morphology as closely as possible. The upper plate includes a segment of the same length as the first inferior segment. The inferior plate is equipped with 4 holes and 4 screws for attaching the flap to the remaining mandible, and 12 holes and 12 screws to secure the 3 segments of the flap. The upper plate is

composed of 3 components: the first connects the upper barrel to the mandible with 3 holes and 3 screws, the second part secures the upper barrel with another 3 holes and 3 screws, and the third part consists of 2 vertical rods that link the upper plate to the lower barrel. These rods overlap the lower barrel and are secured with 2 holes and 2 screws. The fibula flap was successfully integrated, with no plate exposure or infection observed. After 6 months, the upper plate was removed under local anaesthesia, while the lower plate remains in place without causing any discomfort. No complications have been reported.

Discussion

The fibula free flap is widely regarded as one of the most reliable and versatile options for mandibular reconstruction, particularly in cases involving extensive defects resulting from oncologic resection or traumatic injury. Its advantages lie in the considerable length and favourable cortical bone quality, which provide excellent structural support for mandibular contour restoration and facilitate osseointegration of dental implants. Furthermore, the flap can be harvested with a skin paddle or soft tissue component, enabling simultaneous reconstruction of both intraoral and extraoral defects when necessary [4]. In recent years, the integration of VSP has significantly improved the precision and predictability of fibula flap reconstructions. Compared to traditional freehand techniques, VSP enables preoperative simulation, accurate osteotomy planning, and the use of patient-specific cutting guides. These advancements have resulted in improved functional and aesthetic outcomes, reduced operative time, and better alignment of bony segments [6]. Different types of fixation techniques of the fibula flap have been described in the literature. However, there are few studies that thoroughly describe the fixation methods used in the double-barrel technique, including the types of plates and screws employed, and the criteria for selecting one approach over another. This lack of detailed comparative data limits the ability to standardise surgical protocols and makes it more difficult for surgeons to base their choices on evidence-based guidelines. As a result, fixation strategies often rely on individual experience and institutional preferences.

This literature review was conducted using the PubMed, Embase, Scopus, and Web of Science databases. A total of 13 articles were included to identify and summarise the various fixation techniques described in the literature. For each fixation method, only one or 2 representative articles were cited (Tab. I).

One commonly used technique involves stabilising the segments of the lower barrel with a mandibular reconstruction plate, while the upper barrel segments are typically connected using mini-plates. Notably, there is no structural linkage between the lower and upper barrels [7,8]. Although this is a well-established technique, the absence of a connecting plate leads to limited structural integration between the 2 levels. This discontinuity may affect the overall biomechanical stability of the construct, particularly under functional load, potentially influencing the long-term success of the reconstruction. In other cases, the upper barrel can be connected with the lower one with mini-plates [9]. A single-double-single barrel (1-2-1) fibula free flap has also been reported for Brown Class III mandibular reconstruction [10]. However, this technique may not be suitable for all defect morphologies or patient conditions. An alternative approach involves the combination of vascularised and non-vascularised fibular segments: the vascularised portion reconstructs the superior alveolar ridge of the neo-mandible, while the non-vascularised segment is used to recreate the inferior mandibular border [11]. Although this method seeks to balance vascular supply with structural integrity, the non-vascularised portion carries a higher risk of resorption or failure due to its limited blood supply.

Another fixation method involves the use of a titanium mesh to secure the upper barrel to the lower one. According to the authors, the titanium mesh prevents soft tissue from collapsing and infiltrating the graft material [12].

Additionally, a 3-dimensional Bologna plate has been proposed as an alternative to the double-barrel technique. This system mimics the double-barrel configuration, but replaces the lower fibular segment with a CAD-CAM–designed titanium plate that offers mechanical support and anchorage for the flap [13,14]. This approach simplifies the procedure and reduces the need for multiple vascularised bone segments, though it may not offer the same biological integration.

Another technique involves the use of long screws for internal fixation between the upper and lower barrels, avoiding the use of mini-plates and mini-screws. In this method, the reconstruction plate supports the upper barrel, and the lower barrel is secured directly to it using long screws [15,16]. This reduces the number of plates and screws used but demands high technical precision and may compromise mechanical stability, especially under functional load.

In contrast, another study shows fixing the lower barrel with a reconstruction plate, while the upper barrel is attached to the lower one using screws [17]. This technique allows fixation with fewer plates, but again requires meticulous execution and may be less robust in resisting masticatory forces.

Table I. Different fixations techniques.

Study	Fixation technique	Description
He et al. (2011) [7], Chang et al. (2011) [8]	Classic double-barrel (unlinked)	Lower barrel stabilised with a reconstruction plate; upper barrel fixed with mini-plates; no structural linkage between barrels
Chen et al. (2019) [9]	Mini-plate linkage between barrels	Upper barrel connected to lower barrel using mini-plates
Pu et al. (2025) [10]	1-2-1 (single-double-single barrel)	A fibula flap arranged in a single-double-single barrel configuration, used for Brown Class III defects
Lin et al. (2019) [11]	Vascularised + non-vascularised fibular segments	Vascularised segment used for alveolar ridge; non-vascularised segment used to reconstruct mandibular border
Okbra et al. (2025) [12]	Titanium mesh	Lower barrel stabilised with a reconstruction plate; upper barrel connected to lower barrel using a titanium mesh
Tarsitano et al. (2023-2021) [13,14]	3D Bologna titanium plate	Custom-shaped titanium plate mimics the lower barrel of a double-barrel fibula flap
Qu et al. (2017), Wang et al. (2013) [15,16]	Long screws for internal fixation (no mini-plates)	Upper barrel supported by reconstruction plate; lower barrel fixed to it using long screws
González-García et al. (2008) [17]	Long screws for internal fixation (no mini-plates)	Lower barrel stabilised with reconstruction plate; upper barrel fixed to lower using screws
Yang et al (2020) [18], Antúnez-Conde et al. (2021) [19]	Single CAD/CAM plate with vertical rods	One custom plate with vertical rods supports both barrels and maintains vertical dimension

On the other hand, Yang et al. [18] and Antúnez-Conde et al. [19] described the use of a single CAD/CAM plate. In the single-plate method, vertical rods are employed to stabilise the fibula segments and maintain the vertical height of the reconstructed mandible. The advantages include the use of a CAD-CAM PSI double-barrel fibula flap which offers enhanced structural stability and minimises the need for intraoperative adjustments. This approach allows for precise preoperative planning and optimal anatomical fit, improving both functional and aesthetic outcomes. By reducing manual plating during surgery, it also shortens operative time and increases flap viability [20]. However, a limitation of this approach arises during dental implant placement. In some cases, there may be insufficient space to insert implants without first removing the plate. Plate removal typically requires general anesthesia and a more invasive surgical procedure, increasing the risk of infection, postoperative oedema, and patient discomfort. The EASY-WEAR-OFF CAD/CAM PSI double-barrel double-plate system addresses these limitations by enabling the upper plate to be removed under local anaesthesia via a minimally-invasive procedure. This significantly reduces overall surgical trauma and facilitates faster postoperative recovery. Additionally, it eliminates the need for a secondary procedure under general anaesthesia and shortens the overall prosthetic rehabilitation timeline by allowing for implant placement during the same surgical time.



Figure 5. Orthopanoramic at 5-year follow-up; osteointegration of the implants and new left condyle.

To further enhance the quality of peri-implant soft tissue, a free skin graft was harvested from the clavicular region [21]. Peri-implantitis commonly arises due to insufficient soft tissue coverage or inadequate bone volume and quality. In our clinical experience, outcomes have remained stable over a 5-year follow-up period, with no signs of bone resorption or peri-implantitis. The final result of the mandibular reconstruction demonstrated successful remodelling of the distal fibula flap segment, leading to the formation of a neocondyle and restoration of satisfactory masticatory function, with a maximum mouth opening greater than 3 cm (Fig. 5).

Conclusions

Various techniques for synthesising and stabilising the double-barrel flap to the mandible have been described in the literature. The use of CAD/CAM prostheses is associated with improved aesthetic and functional outcomes, while also reducing operative time. Implant-based rehabilitation is essential for patients, as it restores key functions such as mastication, speech, occlusion, and facial aesthetics.

The use of the EASY-WEAR-OFF CAD/CAM PSI double-barrel double-plate system ensures primary stability of the bone segments, creating optimal conditions for osseous consolidation during the initial healing phase. Additionally, the upper component of the double-plate structure is specifically designed for easy removal under local anaesthesia at the time of implant placement. This feature enables a minimally-invasive approach, reduces patient morbidity, and enhances the overall efficiency of the prosthetic rehabilitation process.

Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

RP, RPi: conceptualization; RP, RPi, CGC: validation; RP, CGC: formal analysis, investigation and writing; RPi, FAG, VAM, MDC, NF: resources, data curation and writing – review and editing; RPi, NF: supervision.

Ethical consideration

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from each participant/patient for study participation and data publication.

References

1 Fang F, Chung KC. An evolutionary perspective on the history of flap reconstruction in the upper extremity. Hand Clin 2014;30:109-122. https://doi.org/10.1016/j.hcl.2013.12.001

2 Kramer FJ, Dempf R, Bremer B. Efficacy of dental implants placed into fibula-free flaps for orofacial reconstruction. Clin Oral Implants Res 2005;16:80-88. https://doi.org/10.1111/j.1600-0501.2004.01040.x

3 Trilles J, Chaya BF, Daar DA, et al. Double-barrel versus single-barrel fibula flaps for mandibular reconstruction: safety and outcomes. Laryngoscope 2022;132:1576-1581.https://doi.org/10.1002/lary.29927

4 Hidalgo DA. Aesthetic improvements in free-flap mandible reconstruction. Plast Reconstr Surg 1991;88:574-185.

5 Sozzi D, Cassoni A, De Ponti E, et al. Effectiveness of resective surgery in complex ameloblastoma of the jaws: a retrospective multicenter observational study. Cancers (Basel) 2022;14:4608. https://doi.org/10.3390/cancers14194608

6 Pucci R, Weyh A, Smotherman C, et al. Accuracy of virtual planned surgery versus conventional free-hand surgery for reconstruction of the mandible with osteocutaneous free flaps. Int J Oral Maxillofac Surg 2020;49:1153-1161. https://doi.org/10.1016/j.ijom.2020.02.018

7 He Y, Zhang ZY, Zhu HG, et al. Double-barrel fibula vascularized free flap with dental rehabilitation for mandibular reconstruction. J Oral Maxillofac Surg 2011;69:2663-2669. https://doi.org/10.1016/j.joms.2011.02.051

8 Chang YM, Wallace CG, Tsai CY, et al. Dental implant outcome after primary implantation into double-barreled fibula osteoseptocutaneous free flap-reconstructed mandible. Plast Reconstr Surg 2011;128:1220-1228. https://doi.org/10.1097/PRS.0b013e318230c6a9

9 Chen J, Yin P, Li N, et al. Functional mandibular reconstruction with double-barrel fibular flap and primary osseointegrated dental implants improve facial esthetic outcome. J Oral Maxillofac Surg 2019;77:218-225. https://doi.org/10.1016/j.joms.2018.08.008

10 Pu JJ, Yu X, Pow EHN, et al. Single-double-single barrel (1-2-1) fibula free flap design for functional and esthetic Brown class III mandibular reconstruction. Plast Reconstr Surg 2025;156:E407-E411. https://doi.org/10.1097/PRS.0000000000011950

11 Lin B, Yang H, Yang H, et al. Vascularized combined with nonvascularized fibula flap for mandibular reconstruction: preliminary results of a novel technique. J Craniofac Surg 2019;30:E365-E369. https://doi.org/10.1097/SCS.0000000000005379

12 Okba HA, Helmy ES, Ayad WM, et al. Volumetric bone changes in double barrel vascularized fibula flap used for mandibular reconstruction: a randomized clinical trial. J Craniofac Surg 2025;36:260-264. https://doi.org/10.1097/SCS.0000000000010541

13 Tarsitano A, Ceccariglia F, Bevini M, et al. Prosthetically guided mandibular reconstruction using a fibula free flap: three-dimensional Bologna plate, an alternative to the double-barrel technique. Int J Oral Maxillofac Surg 2023;52:436-441. https://doi.org/10.1016/j.ijom.2022.08.006

14 Tarsitano A, Battaglia S, Corinaldesi G, et al. Mandibular reconstruction using a new design for a patient-specific plate to support a fibular free flap and avoid double-barrel technique. Acta Otorhinolaryngol Ital 2021;41:230-235. https://doi.org/10.14639/0392-100X-N0549

15 Qu X, Wang M, Xu L, et al. Occlusion guided double-barreled fibular osteoseptocutaneous free flap for refined mandibular reconstruction aided by virtual surgical planning. J Craniofac Surg 2017;28:1472-1476. https://doi.org/10.1097/SCS.0000000000003841

16 Wang WH, Zhu J, Deng JY, et al. Three-dimensional virtual technology in reconstruction of mandibular defect including condyle using double-barrel vascularized fibula flap. J Craniomaxillofac Surg 2013;41:417-422. https://doi.org/10.1016/j.jcms.2012.11.008

17 González-García R, Naval-Gías L, Rodríguez-Campo FJ, et al. Vascularized free fibular flap for the reconstruction of mandibular defects: clinical experience in 42 cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:191-202. https://doi.org/10.1016/j.tripleo.2007.04.002

18 Yang WF, Choi WS, Zhu WY, et al. "One-piece" patient-specific reconstruction plate for double-barrel fibula-based mandibular reconstruction. Int J Oral Maxillofac Surg 2020;49:1016-1019. https://doi.org/10.1016/j.ijom.2019.12.006

[19] Antúnez-Conde R, Salmerón JI, Díez-Montiel A, et al. Mandibular reconstruction with fibula flap and dental implants through virtual surgical planning and three different techniques: double-barrel flap, implant dynamic navigation and CAD/CAM mesh with iliac crest graft. Front Oncol 2021;11:719712. https://doi.org/10.3389/fonc.2021.719712

[20] Modabber A, Legros C, Rana M, et al. Evaluation of computer-assisted jaw reconstruction with free vascularized fibular flap compared to conventional surgery: a clinical pilot study. Int J Med Robot 2012;8:215-220. https://doi.org/10.1002/rcs.456

[21] Bouzid L, Lescaille G, Pomes B, et al. Implant retained prosthesis on a free fibula flap: a challenging procedure for prosthetic and soft tissue management. J Prosthet Dent J Prosthet Dent 2025;133:1598-1603. https://doi.org/10.1016/j.prosdent.2023.06.035