Review Article

Chest wall resections for advanced breast cancer: a narrative review

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Background and Objective: Advanced breast cancer (BC) can involve the chest wall through local invasion by the primary tumor, locoregional recurrence, hematogenous metastasis, or sternum infiltration of the internal mammary chain lymph nodes. The purpose of this article is to review indications and the methods of chest wall resection and reconstruction in patients with advanced BC.

Methods: An online literature search was conducted on PubMed database using the following keywords: "chest wall reconstruction" or "chest wall resection" and "breast cancer". Articles in languages other than English were excluded.

Key Content and Findings: The treatment options should be discussed by a multidisciplinary team. The surgical principles include complete *en bloc* resection of the tumor including all involved or damaged skin, muscle and part of chest wall including ribs, complete or partial sternum and clavicles, as required, to achieve wide clear margins. The chest wall defect should be reconstructed with a good functional result. The optimal strategy for chest wall reconstruction depends on factors such as the defect`s size, location, and previous radiation or surgical intervention. A part of the reconstruction involves stabilizing the chest wall. Additionally, the defect should be covered with well-vascularized tissue, often necessitating reconstruction with muscle flaps or myocutaneous flaps.

Conclusions: A resection and reconstruction of the chest wall may be the best treatment option to achieve a high quality of life and favorable long-term outcomes, mostly as part of multimodality treatment for highly selected patients.

Keywords: Breast cancer (BC); chest wall resection; recurrence; reconstruction

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Introduction

Advanced breast cancer (BC) can involve the chest wall through local invasion by the primary tumor, by locoregional recurrence in a previously operated or irradiated area, or hematogenous metastasis. Sternum can also be involved as infiltration of the internal mammary chain lymph nodes (1-4).

Patients with chest wall invasion can suffer disabling symptoms such as pain, compression, ulceration, fungation, bleeding and bacterial contamination with malodorous secretion (*Figure 1*) (5-9).

The options for treatment of BC include hormone therapy, systemic chemotherapy, systemic targeted therapy like antibody, antibody-drug conjugates or immunotherapy, radiation therapy, surgery, or a combination of these approaches (10,11). The decision to perform a resection of the chest wall as well as the method of chest wall defect reconstruction has to be chosen in a highly individualized manner and requires multidisciplinary expertise (12,13). In the absence of metastatic disease for patients with invasion of the musculoskeletal elements of the chest wall, local chest wall recurrences, as well as solitary regional lymph node recurrences surgery may be the best treatment option as it provides local control of the disease and a better quality of life (2,7,14-21). The surgical principles include complete *en bloc* resection of the tumor including all involved or damaged skin, muscle and part of chest wall including ribs, complete or partial sternum and clavicles, as required, to achieve wide clear margins. The chest wall defect should be reconstructed with a good functional result, to ensure protection of intra-thoracic organs and a coverage often using a variety of myocutaneous flaps (8,22-25). The purpose of this article is to review indications and the methods of chest wall resection and reconstruction in patients with advanced BC. We present this article in accordance with the Narrative Review reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1432/rc).

Methods

For the clinical outcomes section, we conducted a literature search on PubMed spanning from 1970 to 2022, using key words “chest wall reconstruction” or “chest wall resection” and “breast cancer”. Articles in languages other than English were excluded. Additionally, we excluded review articles and case reports (*Table 1*).

Chest wall resection: indications and preoperative considerations

Whenever an advanced BC with involvement of the chest wall or recurrent BC of the chest wall is present, some aspects should be taken into consideration when planning treatment strategies. The tumor assessment should include computed tomography (CT) of the chest, as well as magnetic resonance image (MRI) to assess the extend and depth of the lesion which allows the surgeon to plan the margins for chest wall resection. A diagnostic sampling of the tumor (needle biopsy or incisional biopsy) may also be necessary for adequate interdisciplinary evaluation of the patient by (breast-) oncologists, radiation oncologist, and surgeons (12,26). The first therapeutic step in the management of primary BC invading chest wall is usually systemic treatment, which can achieve response and even complete pathological response (27). In the case of response, breast and thoracic surgeons have to determine about the extent of resection. In highly selected patient with complete response to systemic therapy, even the wait and watch strategy is suitable (12). Neoadjuvant chemotherapy is even more important in case of inflammatory BC (28). Another important aspect of therapeutic planning is to decide, whether there is a need for palliative resection to achieve symptom control or in order to prevent life-threatening complications (12).

Technique of chest wall resection and resection margins

The main goal for the surgeon in the management of the extended BC is to provide the best chance for complete resection to achieve locoregional disease control (12,26).

Full-thickness resection of the chest wall including skin, subcutaneous tissue and parietal pleura is often required to perform an *en bloc* resection of the tumor. To achieve histological margins of at least 1 to 2 cm, clinical margins should include approximately 4 to 5 cm of normal rib anterior and posterior as well as one rib cephalad and one rib caudal to the tumor (15,26). Because frozen section is not feasible on bone specimens, this extent can be determined by inspection and analysis of the current radiological imaging, intraoperative inspection and palpation. Wider resections do not reduce the risk of recurrence or offers a survival benefit (29).

Whenever the sternum is infiltrated, clinical examinations as well as analysis of the radiological imaging

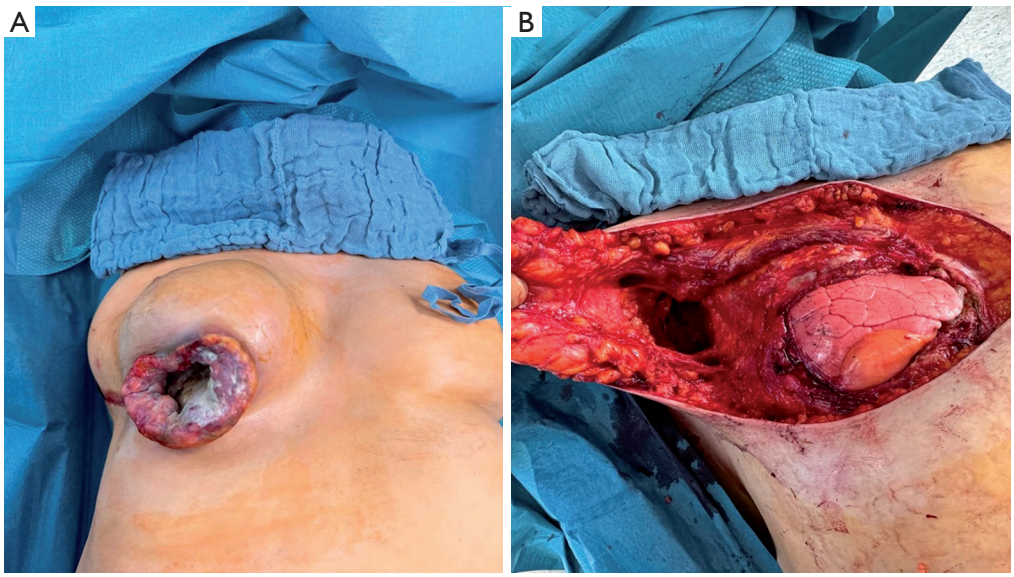

Figure 1 Exulcerating, advanced breast cancer: (A) advanced breast cancer with chest wall invasion with disabling symptoms such as pain, compression, ulceration, fungation, bleeding and bacterial contamination with malodorous secretion; (B) view after complete tumor resection *en-bloc* with full-thickness anterior chest wall resection.

Table 1 The search strategy summary

Items	Specification
Date of search	3rd September 2023
Databases and other sources searched	PubMed
Search terms used	"Chest wall reconstruction" or "chest wall resection" and "breast cancer"
Timeframe	1970 to 2022
Inclusion and exclusion criteria	Articles in languages other than English, review articles and case reports were excluded
Selection process	N.B. selected the studies, and all authors reviewed and approved the final list of studies included in the review

decide about the extend of the resection. In the absence of skin involvement, a midline incision can be made. Otherwise, an elliptical incision on the chest wall should be made with a large radius of normal skin around the lesion. A complete or partial sternal resection including peritumoral soft tissue should be performed to achieve a 4 cm bone margin whenever possible. The complete sternal resection usually requires manubrial resection including the resection of the clavicular heads as well as the cartilaginous portions of the anterior ribs (*Figure 2*) (15,30). A partial sternal resection can include one part of the complete sternum or median resection of the sternum including anterior ribs on the affected side. This kind of partial resection is often needed for involvement of the sternum by lymph node metastasis and a hybrid approach including minimal invasive intrathoracic dissection is feasible in case of limited extent.

In dealing with radiation ulcers, wide excision should be performed since the blood supply is often poor in the radiation-damaged areas (26).

After resection, the affected side or both sides of the pleural cavity should be drained before the reconstruction part starts. Whenever it is necessary to resect the sternum, an additional drainage should be insert subxiphoidal and placed on the mediastinum.

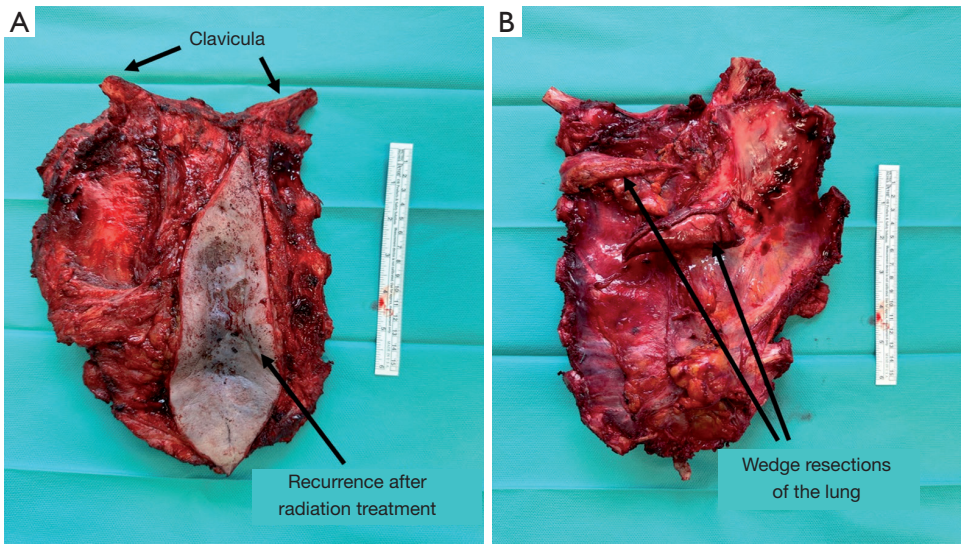

Figure 2 Complete sternal resection: (A) front view of full-thickness complete sternal resection which requires manubrial resection including the resection of the clavicular heads as well as the cartilaginous portions of the anterior ribs; (B) back view of full-thickness complete sternal resection with *en-bloc* wedge resections of the lung.

Reconstruction of the chest wall

The optimal strategy for chest wall reconstruction depends on factors such as the defect's size, location, and previous radiation or surgical intervention (31). For the reconstruction of small chest wall defects, nonrigid materials like Vicryl mesh, Prolene mash, Marlex mash, polytetrafluoroethylene (PTFE) patch, or biological patches can be used. Defects larger than 5 cm in maximum diameter or including 4 or more ribs in the anterior chest wall should be reconstructed with rigid materials to prevent lung herniation or respiratory compromise from paradoxical breathing, or respiratory failure (24,29,32).

There are several ways of how to reconstruct the bony part of the chest wall with rigid materials like titanium implantable material (*Figure 3*) or ceramic sternal prothesis. The authors prefer a Sandwich-Technique including a mesh-methyl methacrylate cement composite graft (*Figure 4*). First described in 1981 by McCormack and colleagues, we use a variation of the "Marlex sandwich", which is composed of methyl methacrylate imbedded between two layers of mash (33). To assemble the sandwich structure, we initiate by suturing the first layer of mesh onto the bony structures (*Figure 4C*). Subsequently, we prepare the methyl methacrylate, carefully monitoring its setting point, and then spread it onto the mesh, effectively covering the area where bony structures were previously removed. To dissipate the generated heat from the bone cement, we immediately cool it with water to protect the mediastinum from excessive heat. Once the methyl methacrylate attains its solidified state, we proceed to suture the secondary mesh layer atop it (*Figure 4D*). The sandwich should be covered with well vascularized muscle layer, with the major pectoralis muscles being the straightforward preference, followed by the closure of the skin.

Whenever it is necessary to perform a full-thickness resection of the chest wall for the treatment of BC, well vascularized tissue is needed to fill the defect and the skin is moved with the muscle flap as a musculocutaneous unit or, if skin is not included, a meshed skin graft can be applied (26). Vacuum assisted closure-therapy of the defect and staged reconstruction can also be considered, especially in infected lesions or advanced soft tissue necrosis. This kind of treatment would require a re-evaluation of the defect after a couple of days and a further debridement if necessary. After this interval, it is possible to determine the time of reconstruction (26).

Pectoralis major flap

Pectoralis major muscle or musculocutaneous flaps are most frequently used for reconstruction of the ventral chest wall because of their proximity, flexibility and reliability with a low complication rate (34). Pectoralis major muscle has a

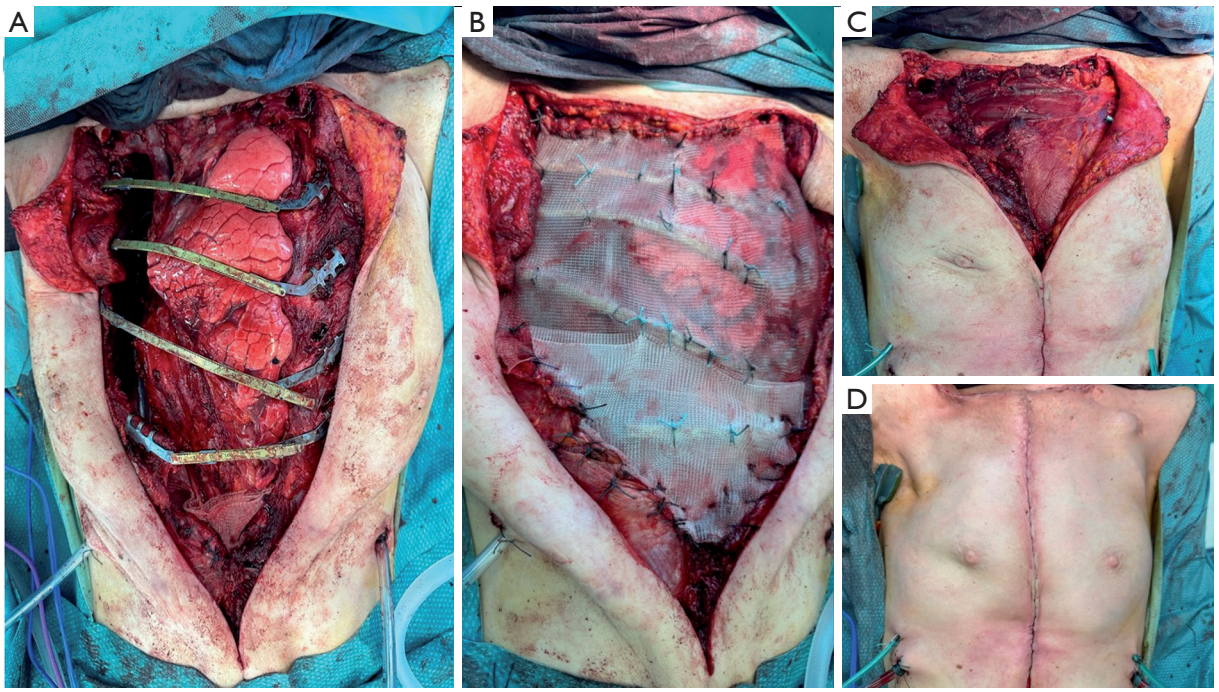

Figure 3 Chest wall reconstruction with titanium bars: (A) view of a large anterior chest wall defect and chest wall reconstruction with titanium bars after full-thickness resesction of an areal breast carcinoma recurrence following prior resection and radiochemotherapy; (B) fixation of a mesh to the titanium bars; (C) muscular coverage of the defect with local muscle flaps; (D) cosmetic result after skin closure.

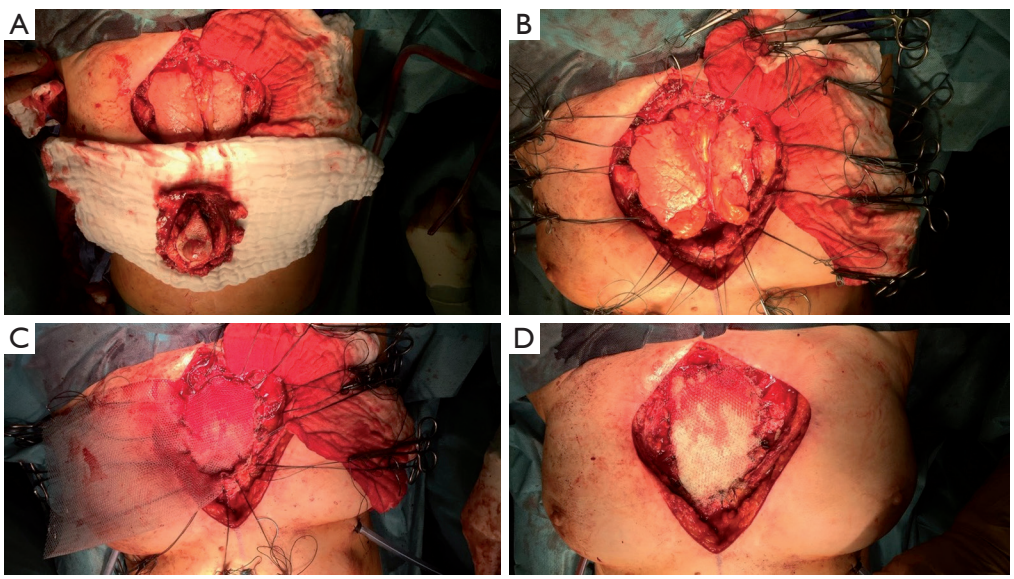

Figure 4 Sandwich-Technique including a mesh-methyl methacrylate cement composite graft: (A) view after full-thickness, partial resection of the sternum; (B) attachment of non-resorbable sutures to bony structures of the anterior chest wall; (C) suturing the first layer of mesh into the defect; (D) suturing the second layer of mesh into the defect.

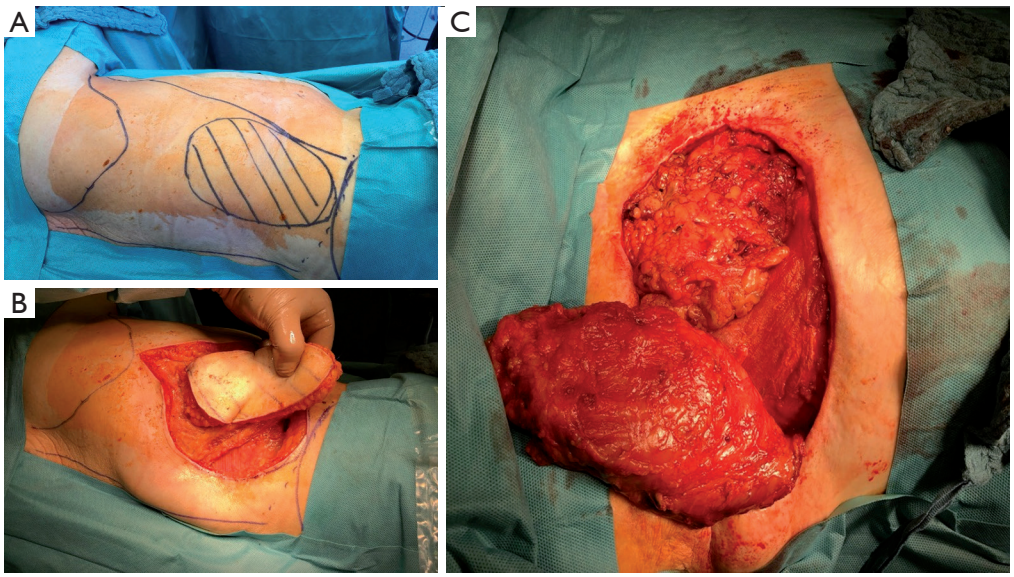

Figure 5 Myocutaneous latissimus dorsi muscle flap: (A) careful drawing of the myocutaneous flap in the area of the M. latissimus dorsi; (B) dissection and preparation of the myocutaneous latissimus dorsi muscle flap; (C) tunneling of the myocutaneous latissimus dorsi flap ventrally before insertion into the anterior defect.

dual blood supply. The pectoralis and the clavicular branch of the thoracoacromial trunk are the primary vascular supply to all but the medial and lateral muscle border. A second vascular supply comes from perforating branches of the internal mammary vessel (35,36). Since musculocutaneous perforators are connecting the intramuscular vessels with the overlying skin, skin paddles can also be placed on the muscle surface (8,9). Whenever bilateral pectoralis flaps (*Figure 3C*) are mobilized and the defect can not be covered in total, the muscle origin can be sectioned from the humerus under direct vision to increase the mobility of the flap (36).

Latissimus dorsi flap

The latissimus dorsi flap can be used as a muscle or a musculocutaneous flap, deriving its vascular supply primarily from the thoracodorsal artery, a branch of the subscapular artery stemming from the axillary artery (37). Survival of the latissimus can also be sustained via retrograde flow from the serratus branch into the thoracodorsal artery (38). To get a musculocutaneous flap, a triangular or oval skin island should be drawn into a horizontal position, the incision deepened until the muscle is reached and the dissection proceeded in the muscular plane to the iliac crest and the scapular bone. The muscle can then be harvested and shifted anteriorly (*Figure 5*). To avoid seroma, suction drains should be inserted to the donor site, to the axilla, and to the chest wound. After closure of the donor wound, the flap can be anchored and the wound can be closed in layers (39,40).

There are still many other soft tissue reconstruction techniques like transverse rectus abdominus myocutaneous (TRAM) flap, vertical rectus abdominus myocutaneous (VRAM) flap, omental flap or free flaps.

Complications of chest wall reconstruction

Mortality rates after chest wall resection and reconstruction in advanced BC are low (0% to 0.8%), morbidity rates vary from 21% to 38% (2,17,21,30,41,42). Wound healing complications have been reported most frequently. Wound vacuum coverage can help to achieve healing in wound infections, but the removal of prosthetic reconstructions is needed in most cases (43,44). Pulmonary complications like pneumonia or respiratory failure can also occur (17,30). In order to minimize the risk of seroma formation, an adequate number of soft tissue drains should be left until the drainage is less than 25 mL per day (36).

Clinical outcomes

During the last decades, several reports have been published

Table 2 Summary of publications for chest wall resection in breast cancer

Author (reference)	Year	No. of patients	1-year survival (%)	3-year survival (%)	5-year survival (%)	Median survival (months)
Zhu *et al.* (9)	2022	75				204
Sponholz *et al.* (42)	2018	18	77	39	39	32
Ahmad *et al.* (30)	2015	24			58	
Shen *et al.* (21)	2013	44			31	
Levy Faber *et al.* (41)	2013	33	100	81	63	69
Koppert *et al.* (44)	2010	17			40	
Noble *et al.* (45)	2010	17	87		38	57
van der Pol *et al.* (2)	2009	77	94		25	40
Veronesi *et al.* (6)	2007	15	77			23
Santillan *et al.* (17)	2008	28			18	23
Pameijer *et al.* (25)	2005	22			71	
Pfannschmidt *et al.* (46)	2005	33			40	41
Downey *et al.* (5)	2000	38	74	41	18	
Toi *et al.* (47)	1997	15		59	47	
Faneyte *et al.* (8)	1997	44			45	58
Brower *et al.* (15)	1992	5				17
Miyauchi *et al.* (7)	1992	23			48	37
Kluiber *et al.* (48)	1991	12				27
Noguchi *et al.* (49)	1988	9				30
Zoetmulder *et al.* (50)	1988	30			50	
McKenna *et al.* (51)	1984	43	72			
Shah *et al.* (14)	1975	52			43	

on chest wall resection and reconstruction for advanced or recurrent BC with curative intent or palliation. *Table 2* gives an overview of the literature. Most of the reports were case series that included between 5 and 77 patients with various treatment modalities and 5-year survival rates ranging from 18% to 71%.

Conclusions

Chest wall resection and reconstruction for advanced BC can be effectively performed in centers with high level of expertise. In the majority of cases, a multimodality treatment with a multidisciplinary framework is essential to achieve a high quality of life and favorable long-term outcomes for the patients.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All clinical procedures described in this study were performed in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patients for the publication of this article and accompanying images.

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