



# International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958  
P-ISSN: 2706-6630  
IJOS 2022; 8(3): 236-238  
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[www.orthopaper.com](http://www.orthopaper.com)  
Received: 14-05-2022  
Accepted: 18-06-2022

**Dr. Wenlin Wang**  
Professor, Department of Chest  
Wall Surgery, Guangdong  
Second Provincial General  
Hospital, Guangzhou, China

**Dr. Weiguang Long**  
Associate Professor, Department  
of Chest Wall Surgery,  
Guangdong Second Provincial  
General Hospital, Guangzhou,  
China

**Dr. Yang Liu,**  
Resident Doctor, Department of  
Chest Wall Surgery, Guangdong  
Second Provincial General  
Hospital, Guangzhou, China

**Dr. Bin Cai**  
Resident Doctor, Department of  
Chest Wall Surgery, Guangdong  
Second Provincial General  
Hospital, Guangzhou, China

**Dr. Juan Luo**  
Resident Doctor, Department of  
Chest Wall Surgery, Guangdong  
Second Provincial General  
Hospital, Guangzhou, China

**Corresponding Author:**  
**Dr. Wenlin Wang**  
Professor, Department of Chest  
Wall Surgery, Guangdong  
Second Provincial General  
Hospital, Guangzhou, China

## Reconstruction of chest wall with MatrixRIB plate after sternal tumor resection in children

**Dr. Wenlin Wang, Dr. Weiguang Long, Dr. Yang Liu, Dr. Bin Cai and Dr. Juan Luo**

DOI: <https://doi.org/10.22271/ortho.2022.v8.i3d.3205>

### Abstract

Chest wall tumor surgery generally includes two parts, one is tumor resection the other is chest wall reconstruction. Tumor resection is relatively simple, and the focus of reconstruction surgery is the selection of materials. MatrixRIB plate is a practical reconstruction material. It can not only be used for reconstruction of ribs and costal cartilages, but also for reconstruction of sternum, so it can be used as the preferred material for reconstruction of chest wall. For the children patients, since the development of chest wall is involved, it is necessary to observe whether it affects the development of bone structure after reconstruction with MatrixRIB plate. If there is an impact, another operation is required for a new reconstruction.

**Keywords:** Children, sternal tumor, surgery, chest wall reconstruction, MatrixRIB plate

### Introduction

Chest wall tumor is a kind of chest wall disease and a common malignant disease [1, 2]. Sternal tumor is a kind of chest wall tumor, but it is relatively rare, especially in children. Because of the serious harm of the tumor, once diagnosed it needs surgical resection. Removing the tumor means that the normal sternum should also be partially removed, which will leave obvious chest wall defects. In order to restore the integrity of the chest wall, it is necessary to reconstruct the chest wall [3, 4]. Generally, sternal tumor surgery includes two parts, one is tumor resection, and the other is chest wall reconstruction. Both parts have special technical requirements. In order to ensure the smooth completion of the operation, efforts must be made in many details. Recently, we performed surgical treatment on an 8-year-old child with sternal tumor. We used MatrixRIB plate for chest wall reconstruction and obtained satisfactory results.

### Case Report

The patient is 8-year-old boy. He was found a mass in the upper part of the anterior chest wall one year ago, which was about the size of a thumb and accompanied by mild pain. The tumor began to grow 3 months ago. Recently, he was admitted to our hospital for surgical treatment. Preoperative physical examination showed that there was a mass in the middle and upper part of the anterior chest wall, which was 5x5 cm in size, accompanied by tenderness and unclear boundary [Fig 1]. Imaging examination showed a mass at the upper end of the sternum. The mass invaded the sternal manubrium and sternal angle, involved the first and second costal cartilage on both sides, but did not invade the clavicle [Fig 2, 3]. The operation of the patient was performed under general anesthesia. In the supine position, a longitudinal incision was made on the surface of the mass. The mass was exposed at first, and then the costal cartilages on both sides along the circumference of the mass were cut, including the right 1<sup>st</sup> to 3<sup>rd</sup> and the left 1<sup>st</sup> and 2<sup>nd</sup> costal cartilages. The sternum below the mass was transected and lifted cephalically. After the sterno clavicular joint was cut, the mass was completely removed. The chest wall was reconstructed with MatrixRIB plate, using steel wires instead of screws for fixing. At first, two MatrixRIB plates were placed between the two sternal ends of clavicle and the residual part of the sternum, with the lower ends of the two plates are crossed and fixed on

the remaining sternum below, and then another MatrixRIB plate was placed between the residual ends of the left and right second ribs and was fixed. Because the third costal cartilage on the right side was removed during the removal of the mass, another plate was used to reconstruct the defect. After the main defect was reconstructed, a mesh was woven between MatrixRIB plates and bone structures with steel wires to reinforce relevant structures and eliminate the large gap between MatrixRIB plates. The MatrixRIB plates were padded on the inner and outer sides with two layers of fibrous membrane. Drainage tubes were placed in both thoracic cavities and surgical fields. After the incision was closed, the operation was completed [Fig 4]. The total operation time was 90 minutes, and the intraoperative bleeding was 20 ml. No complications occurred during the operation. The postoperative recovery was smooth without any complication, and no paradoxical breathing was found on the chest wall. Postoperative X-ray examination showed that the position of MatrixRIB plates was satisfactory [Fig 5]. The patient was discharged 7 days after operation.

### Discussion

Chest wall tumors can invade various structures of the chest wall, and bone structures are the most frequently invaded structures. The bony structures of chest wall include sternum, costal cartilage and ribs. All three structures may develop tumors. Sternal tumors are relatively rare. Due to the special position and important function of the sternum, proper reconstruction is required after resection of the tumor [1, 2].

The sternum is the most important supporting structure of the anterior chest wall. When part of the sternum is removed with the tumor, special materials need to be used for reconstruction. In the past, a variety of materials have been used for this kind of surgery, but there are some problems with these materials [3, 4]. 3D printing materials have received attention in recent years [5]. Theoretically, this kind of material has the advantages of personalization and is the most ideal material. However, in practical application, some specific difficulties cannot be overcome. For example, such materials must be processed temporarily, and patients need to wait a long time before receiving surgery. In addition, it is sometimes difficult to be placed during surgery, which is obviously not commensurate with the characteristics of its personalized design. Therefore, at least for now, this material needs to be improved.

MatrixRIB plate is a fixation material designed for rib fractures [6]. In later applications, some people began to use it for chest wall reconstruction [7, 8]. We found the possibility of using it for chest wall reconstruction very early, so we completed many related operations. We use it not only for the reconstruction of rib and costal cartilage defects, but also for the reconstruction of sternum defects, and has accumulated a lot of experience.

MatrixRIB plate has the following advantages when used for the chest wall reconstruction: (1) There are ready-made MatrixRIB plate of different specifications in clinic, and there is no need for temporary processing; (2) MatrixRIB plate has strong mechanical strength and certain elasticity, which can meet the physiological needs; (3) The radius and length of MatrixRIB plate can be temporarily adjusted during the operation according to needs of the operation to the maximum extent, which can make reconstruction surgery very convenient; (4) MatrixRIB plate can be used not only for reconstruction of sternum, but also for reconstruction of ribs and costal cartilages, which will make this material more

practical. Obviously, these advantages can meet various requirements of chest wall reconstruction, therefore, MatrixRIB plate should be an ideal reconstruction material.

When MatrixRIB plate is used, the standard fixing method is to use special screws [7, 8]. This method is the most ideal fixation method. However, in some specific cases, it is very difficult to fix with screws, or it is impossible to obtain a firm effect. At this time, we will use steel wire to fix directly. Our experience shows that this method can also achieve satisfactory results. In addition, when fixing some special parts, the steel wire fixing will be simpler and more convenient.

When MatrixRIB plate is used for chest wall reconstruction, because it is relatively thin, wide gaps will be formed between MatrixRIB plates or between MatrixRIB plates and ribs. If these gaps are not handled, they may lead to herniation of lung tissue and paradoxical breathing. In order to eliminate these drawbacks, it is necessary to eliminate these gaps. The method includes two aspects, one is to use steel wires to weave a mesh between MatrixRIB plates, and the other is to use fibrous membrane as cushions inside and outside MatrixRIB plates. After such treatment, the gaps can be basically eliminated.

The shape of MatrixRIB plate is designed according to the shape of ribs, so it seems more reasonable to use it for rib or costal cartilage reconstruction. Theoretically, the reconstruction of the sternum needs to construct the shape of the sternum, which seems to be a basic requirement. However, we found in clinic that reconstruction can be achieved as long as the defect after sternal resection can be repaired, the thoracic structure can be stabilized, and paradoxical breathing can be avoided. This goal can be easily achieved using MatrixRIB plate, so it can also be used for sternal reconstruction.

The reconstruction of chest wall in adult is relatively simple and does not need to consider the development of bone structures, but the bone of children patients needs to grow further, which has more requirements for reconstruction surgery. Since no artificial material can grow itself, any reconstruction operation performed with artificial materials cannot solve the growth problem. MatrixRIB plate is also an artificial material and also cannot grow with the development of the body. However, due to its shallow location, it is convenient to remove when needed. If necessary, it can also be conveniently replaced with larger plates. Nevertheless, this possibility may not necessarily occur, because the remaining ribs and sternum may still continue to develop. If the MatrixRIB plate does not significantly restrict development, there is no need for reoperation.

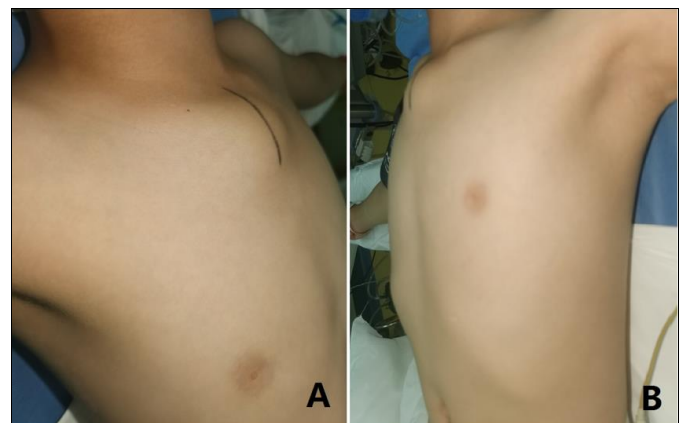
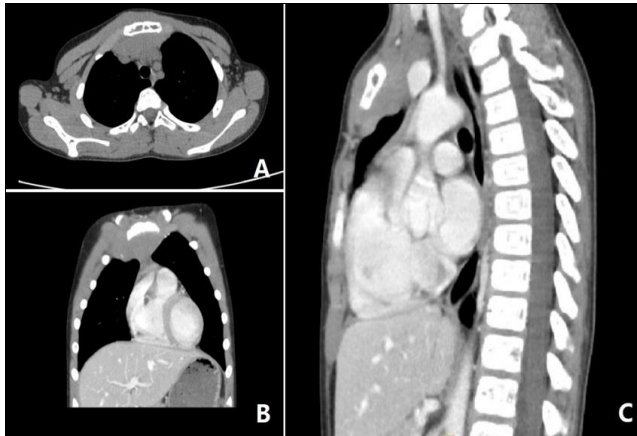
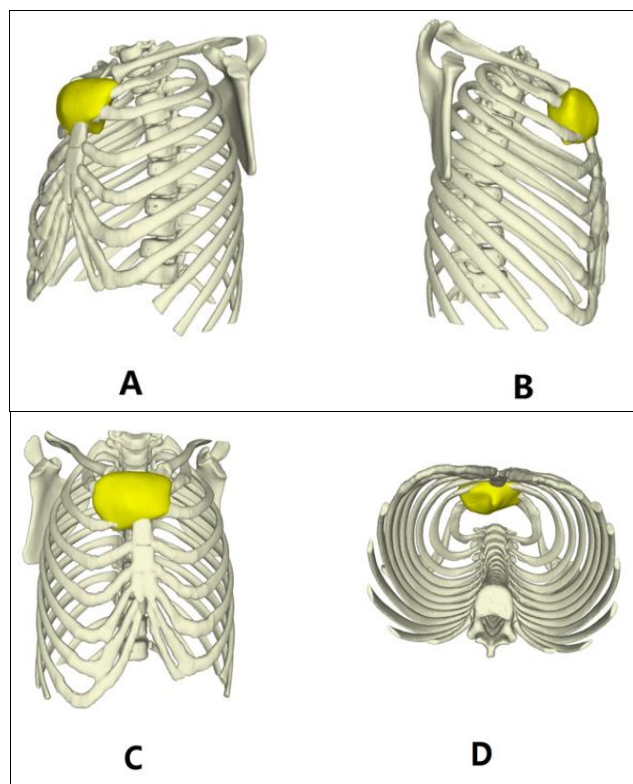


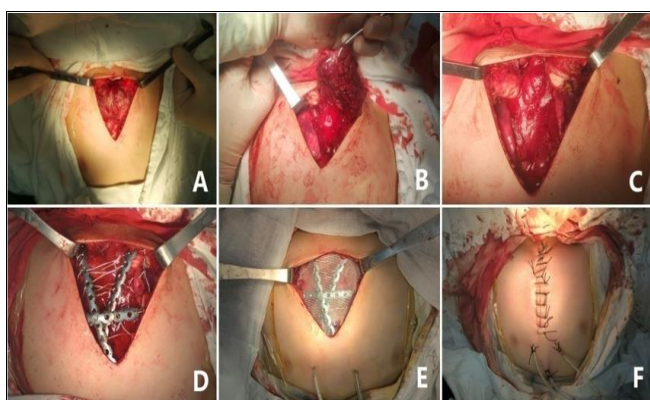
Fig 1: Location of sternal tumor on the body surface.



**Fig 2:** Imaging examination shows the location of sternal tumor



**Fig 3:** Three dimensional reconstruction image of the chest wall, showing the location of the sternal tumor.



**Fig 4:** Operation pictures. A. Tumor exposure; B. Tumor resection; C. Chest wall defect after tumor resection; D. The bone structure of chest wall was reconstructed with MatrixRIB plates; E. MatrixRIB plates were covered with fibrous membrane; F. The incision was sutured



**Fig 5:** X-ray examination of chest after operation.

### Conclusion

Our experience shows that MatrixRIB plate is a practical reconstruction material, which can be flexibly used for chest wall reconstruction. For children patients, this material can also meet the needs of surgery. If the development of residual bone structures is not constrained by MatrixRIB plates, they can be placed in the body for a long time without taking out. If the MatrixRIB plate restricts the growth of the bone structures, it needs to be removed in the future and reconstructed again.

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