

*Chondrotomy and sternotomy combined
with the Nuss procedure for severe
asymmetric pectus excavatum: how to do it*

**Hisako Kuyama, Sadashige Uemura &
Atsushi Yoshida**

Surgery Today

Official Journal of the Japan Surgical
Society

ISSN 0941-1291

Surg Today

DOI 10.1007/s00595-020-02153-w



Your article is protected by copyright and all rights are held exclusively by Springer Nature Singapore Pte Ltd.. This e-offprint is for personal use only and shall not be self-archived in electronic repositories. If you wish to self-archive your article, please use the accepted manuscript version for posting on your own website. You may further deposit the accepted manuscript version in any repository, provided it is only made publicly available 12 months after official publication or later and provided acknowledgement is given to the original source of publication and a link is inserted to the published article on Springer's website. The link must be accompanied by the following text: "The final publication is available at link.springer.com".



Chondrotomy and sternotomy combined with the Nuss procedure for severe asymmetric pectus excavatum: how to do it

Hisako Kuyama¹ · Sadashige Uemura² · Atsushi Yoshida¹

Received: 25 June 2020 / Accepted: 9 September 2020

© Springer Nature Singapore Pte Ltd. 2020

Abstract

The correction of severe asymmetric pectus excavatum is still challenging, especially for adults with a rigid thorax. For the repair of asymmetric cases, we introduce our surgical techniques added to the Nuss procedure. Chondrotomy of the depressed and deformed costal cartilage to elevate the depressed side was performed in a 42-year-old female patient. The depressed chest wall was directly elevated using pectus bars. Her sternal rotation angle improved from 27° to 15° after bar removal. In a 26-year-old male patient, oblique sternotomy and chondrotomy were performed. The sternal rotation angle improved from 26° to 9° postoperatively. These techniques were effective for correcting severe asymmetric pectus excavatum in adults.

Keywords Nuss procedure · Chondrotomy · Sternotomy

Introduction

Pectus excavatum (PE) is the most frequent deformity of the thorax. PE, which is characterized by a depression of the anterior chest wall, varies in morphology among cases. Asymmetry is one of the most important factors in the morphology of PE, as it greatly affects the cosmetic results after surgical repair. Several authors have pointed out that asymmetry may progress during the time of growth [1, 2]. In addition, asymmetric PE correlates strongly with sternal rotation [1]. The correction of severe asymmetric PE with sternal rotation is still challenging, especially in adults with a rigid chest wall.

The surgical techniques that were added to the Nuss procedure to correct sternal rotation are presented here.

Methods

The evaluation of thoracic deformity

The degree of the defect in patients with pectus excavatum was assessed based on the Haller index (HI) and correction index (CI) on computed tomography (CT) [3]. In addition, the sternal rotate angle in each patient was measured at the level of the lower sternum.

Surgical techniques

Chondrotomy

Based on preoperative CT, the deformed costal cartilage is selected for chondrotomy. A midline incision, 2- or 3-cm long, is made on the lower anterior chest wall. In female cases, a submammary line incision on the affected side may be preferred. After dissecting the pectoralis major muscle from the ribs, the deformed 4th to 7th costal cartilage is exposed and incised halfway in the acutely angled spots. When the depression extends to the 3rd and 4th costal cartilage, a thoracoscopic incision is made using electric cautery, and partial resection by rongeurs is performed. The Nuss procedure is then performed using an appropriate number of bars. The depressed costal cartilage is pushed directly up by the bars. Figure 1 shows a schematic illustration of the chondrotomy procedure.

✉ Hisako Kuyama
hkuyama@med.kawasaki-m.ac.jp

¹ Department of Pediatric Surgery, Kawasaki Medical School, 577 Matsushima, Kurashiki-City, Okayama 701-0192, Japan

² Nishinomiya Watanabe Cardiovascular Center, 3-25 Ikeda-Cho, Nishinomiya-City, Hyogo 662-0911, Japan

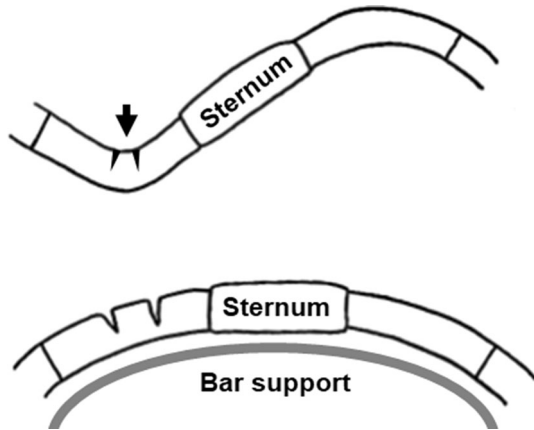


Fig. 1 Schematic illustration of the chondrotomy procedure. The black arrow shows the incision points on the deformed cartilage

Sternotomy

Sternotomy is considered in cases with a severely twisted sternum (Fig. 2a) and performed at the same time as chondrotomy. After chondrotomy, the anterior sternal cortex is resected in a wedge-shape using a bone saw (Fig. 2b). This oblique incision line is determined in accordance with the ridge of the sternal twist. Two bars are then used to repair the depression.

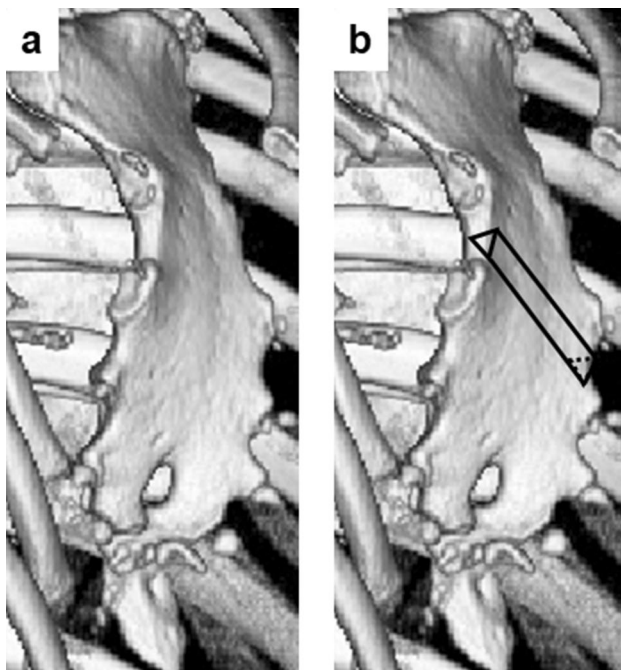


Fig. 2 Schematic illustration of the oblique sternotomy procedure. **a:** Three-dimensional CT image of the severe twisted sternum. **b:** The black triangular prism shows the resected sternal cortex

Results

Chondrotomy was performed for a 42-year-old female patient (Patient one), and chondrotomy plus sternotomy was performed for a 26-year-old male patient (Patient two).

Patient one is preoperative chest appearance showed asymmetric PE with broad and right-sided depression. The HI was 9.3, and the CI was 58.6. The sternum from the level of the 2nd to the 7th rib was leaning to the right, and the maximum rotation angle was 27° against the horizontal line. Chondrotomy was performed with a right partial submammary incision, 2.5 cm long, on the lower anterior chest wall (Fig. 3). The right deformed 5th to 6th costal cartilage was incised via the anterior wall, and the right 3rd and 4th costal cartilage was incised thoracoscopically. Three bars were used to correct the chest wall depression. The patient's postoperative course was uneventful. Three years later, the bars were removed, and postoperative CT showed that the sternal rotation angle had improved to 15° (Fig. 4).

Patient two had asymmetric PE with right-sided depression. Chest CT showed a bifid rib (right third rib). The HI was 3.48, and the CI was 34.5. The sternum was acutely twisted at the 3rd costosternal junction (CSJ), and the maximum rotation angle was 26° against the horizontal line. Chondrotomy and sternotomy were performed with a mid-line incision, 3 cm long, on the lower anterior chest wall (Fig. 5). The right deformed 4th to 6th costal cartilage was incised, and then a wedge-shaped incision of the sternal cortex along the line from the right 3rd intercostal space to left

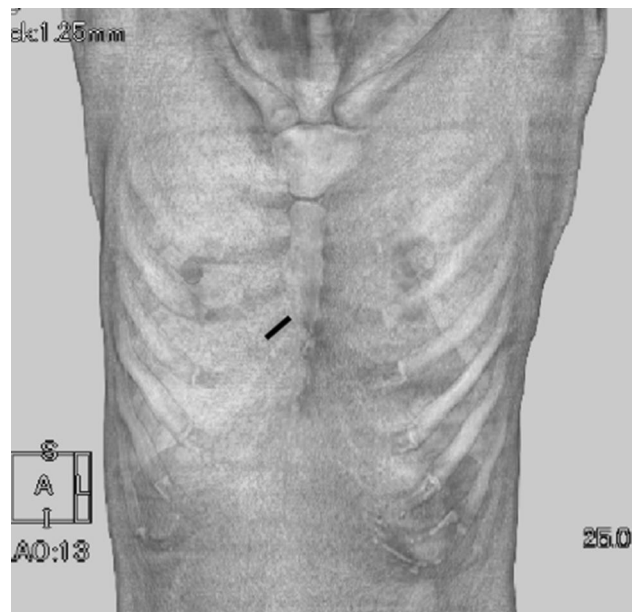


Fig. 3 The site of a submammary incision (patient one). The black line shows the submammary line incision for chondrotomy

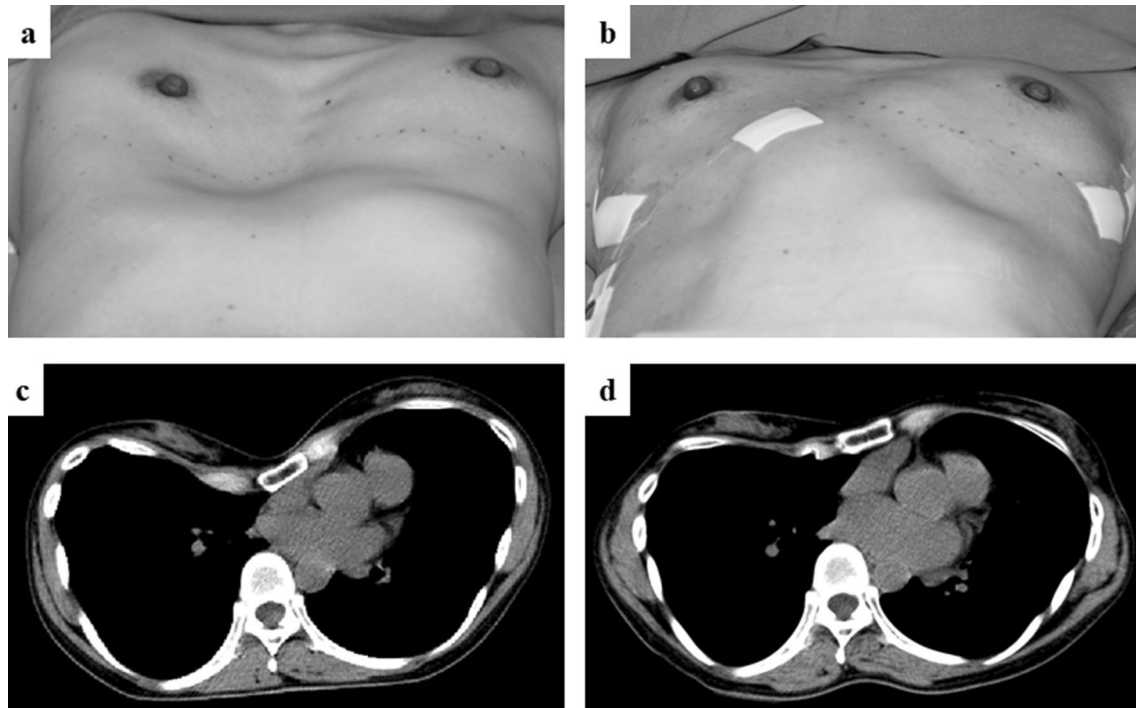


Fig. 4 CT images and chest appearance before and after the Nuss procedure (patient one). **a** Preoperative chest appearance, **b** Postoperative chest appearance, **c** Preoperative CT images, **d** Postoperative CT images

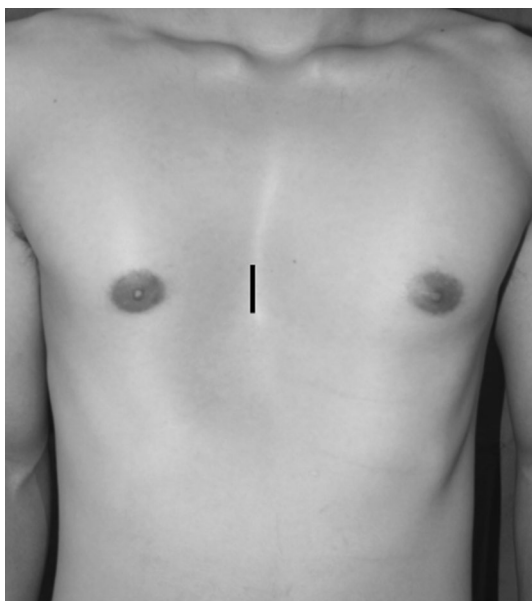


Fig. 5 The site of a midline incision (patient two). The black line shows the midline incision for chondrotomy and sternotomy

4th intercostal space was made. Two bars were used to correct the chest wall depression. There were no problems after the operation, and he underwent bar removal 3 years later. Postoperative CT after bar removal showed improvement of

the chest depression, and the sternal rotation had improved to 9° (Fig. 6).

Discussion

The Nuss procedure has been established as minimally invasive surgery for PE in children and young adolescents and is currently the most commonly used standard treatment. However, the Nuss procedure for adults who have a rigid thorax is not entirely minimally invasive. Intra-operative and postoperative complications, such as damage to the intercostal muscles and bar migration, have been reported [4]. Some modified procedures, such as resection of the costal cartilage and sternal osteotomy, have been reported as methods of treating adults' rigid thorax [4–7].

Conversely, there have been no reports of surgical procedures to correct asymmetric PE. In this report, two adult cases with severe asymmetric PE who underwent the Nuss procedure with additional surgical procedures of chondrotomy and sternotomy were presented. In patient one, the whole body of the sternum leaned to the right side. Therefore, chondrotomy of the depressed right cartilages was performed. In patient two, the lower half of his sternum had twisted severely to the right side, and the twist would have remained even with sternal elevation by the pectus bars. Therefore, oblique sternotomy was added to chondrotomy.

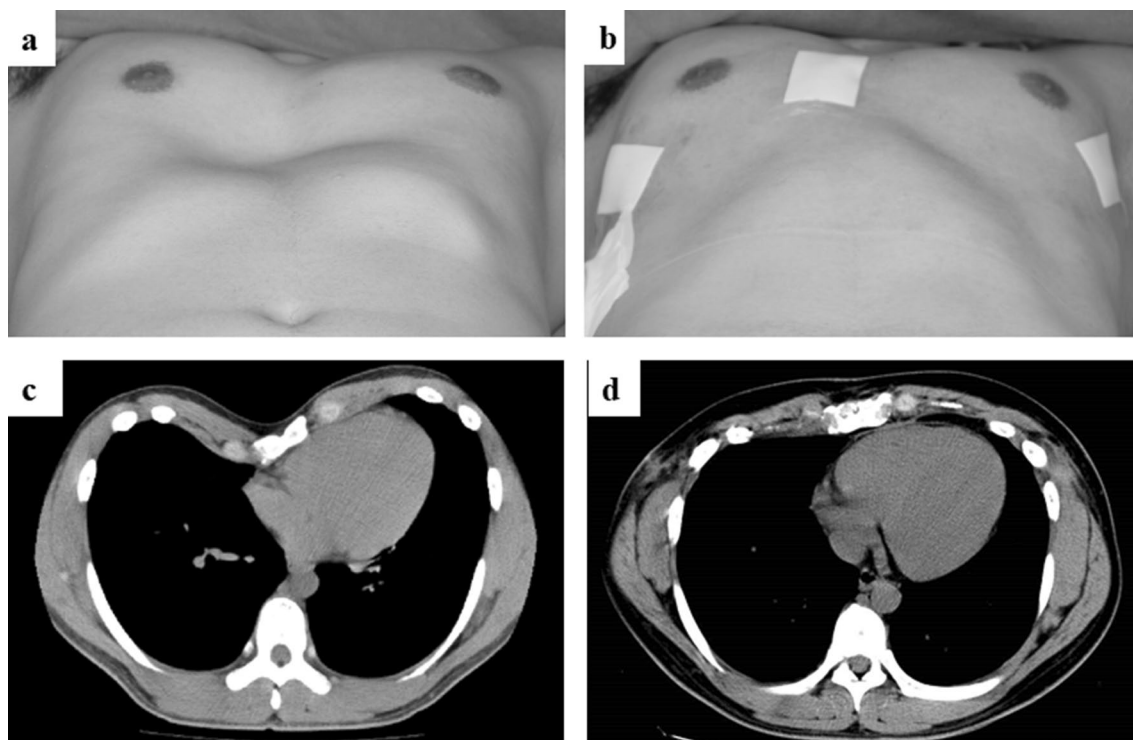


Fig. 6 CT images and chest appearance before and after the Nuss procedure (patient two). **a** Preoperative chest appearance, **b** Postoperative chest appearance, **c** Preoperative CT images, **d** Postoperative CT images

In both cases, great improvement was observed in the chest appearance and the sternal rotation angle after bar removal.

In conclusion, chondrotomy of the curved costal cartilage and sternotomy are effective for adults with severe sternal tilt and twisting. Further investigations will be needed to determine the effectiveness of this procedure in relation to the degree of sternal rotation and the age group requiring these techniques.

Compliance with ethical standards

Conflicts of interest All authors have no conflicts of interest.

References

1. Yoshida A, Uemura S, Yamamoto M, Nouso H, Kuyama H, Muta Y. Correlation of asymmetric chest wall deformity and growth in patients with pectus excavatum. *J Pediatr Surg.* 2013;48:771–5.
2. Nuss D, Obermeyer RJ, Kelly RE. Pectus excavatum from a pediatric surgeon's perspective. *Ann Cardiothorac Surg.* 2016;5:493–500.
3. Sujka JA, St Peter SD. Quantification of pectus excavatum: anatomic indices. *Semin Pediatr Surg.* 2018;27:122–6.
4. Jaroszewski DM, Ewais MM, Chao CJ, Gotway MB, Lackey JJ, Myers KM, et al. Success of minimally invasive pectus excavatum procedures (modified Nuss) in adult patients (≥ 30 years). *Ann Thorac Surg.* 2016;102:993–1003.
5. Dzielicki J, Korlacki W, Janicka I, Dzielicka E. Difficulties and limitations in minimally invasive repair of pectus excavatum - 6 years experiences with Nuss technique. *Eur J Cardio-Thoracic Surg.* 2006;30:801–4.
6. Velazco CS, Arsanjani R, Jaroszewski DE. Nuss procedure in the adult population for correction of pectus excavatum. *Semin Pediatr Surg.* 2018;27:161–9.
7. Al-Assiri A, Kravarusic D, Wong V, Dicken B, Milbrandt K, Sigallet DL. Operative innovation to the “Nuss” procedure for pectus excavatum: operative and functional effects. *J Pediatr Surg.* 2009;44:889–92.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.