Titanium plate osteosynthesis for the correction of severe sternal deformity in a 13-year-old boy

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Abstract

In a 13-year-old boy a correction of an atrioventricular septal defect (AVSD) was performed at the age of one year and a mitral valve reconstruction at the age of two years. The patient developed, after two median sternotomies, a massive sternal deformity. At the age of 12 years another mitral valve reconstruction had to be performed. At this time titanium plates were used for sternal closure and correction of the deformity. Six months later, and after a CT-follow-up, the plates could be removed with a very satisfying result. Sternal plate osteosynthesis represents an excellent alternative for the correction of difficult sternal closures and deformities in adults as well as in children.

Keywords: Sternal deformity; Sternal plate osteosynthesis

1. Introduction

Chest wall and sternal deformities are relatively rare and the most common cause is congenital in the form of sternal malformations like pectus excavatum and carinatum. The surgical correction is difficult, containing muscle dissections, osteotomies and the use of wires [1-4]. However, besides congenital chest wall deformities, also sternal deformities can develop after multiple sternotomies in cardiac surgical patients. These types of sternal deformity are primarily seen in children requiring multiple sternotomies for cardiac surgical procedures which have to be performed in the growth phase.

Due to the successful application of specially designed titanium plates (Synthes, Switzerland) for different sternal complications like sternal fractures and infections as well as pseudoarthrosis [5-7], we decided to use these plates for chest closure with a severe sternal deformity in a 13-year-old boy after his third cardiac surgical procedure.

2. Case report

After an AVSD correction at the age of one year and mitral valve reconstruction at two years. Ten years later the boy developed a massive sternal deformity after these two sternotomies (Fig. 1a–c). At the age of 13 years, another mitral valve reconstruction was necessary and the plan was to correct his sternal deformity at the same time.

After successful mitral valve reconstruction the sternum was reconstructed and closed with titanium plates. Both sternal halves were shaped with little bone removal, and brought together with reposition clamps. With the exception of the manubrium the approximation was satisfactory. In the remaining gap synthetic bone material was added. Four titanium plates were installed with 3.0 unilock screws with lengths of 10–14 mm. The result was a stable and well-shaped sternum (Fig. 2a–c).

The initial follow-up after three months showed a good positioning of the plates with perfectly shaped sternum, and the patient was doing fine. After six months the plates were still in a good position, whereas in the manubrium plate a slight loosening of two screws was visible. Also, the gap was still visible whereas the rest of the sternum was well shaped (Fig. 2b). Because of the complete consolidation of bone repair we decided to remove the plates, which was carried out without complications (Fig. 2d). Surprisingly, the region of the gap which was visible in the CT was completely stable due to alternative bone which developed from the synthetic material and was not visible in the X-ray. Also, the rest of the sternum was well shaped and stable (Fig. 2e).

In the 8-month follow-up the boy showed no discomfort without restriction and a very satisfying cosmetic result.

3. Discussion

The development of sternal deformities in patients with congenital structural heart disease and the need for multiple cardiac surgeries through median sternotomies is rare.
However, the cause and also the risk for this development is not clear yet. Furthermore, these deformities differ significantly in shape from congenital sternal deformities like pectus excavatum or carinatum. For these pathologies different operating techniques are described and also successfully applied. A very important difference between patients with congenital sternal deformities and patients with congenital structural heart disease is the fact that patients with congenital deformities are otherwise mostly healthy. In these cases a very complicated and extensive surgery to correct the sternal deformity is much better tolerated compared to patients who have to undergo additional cardiac surgery. Therefore, surgery for the correction of sternal deformities in cardiac patients should be as easy and as short as possible. In addition, the psychological factor should not be underestimated, especially in children with congenital heart disease, who probably suffer more from a sternal deformity.

Since we have a vast experience with titanium plates in adult cardiac patients with sternal fractures, sternal infections and pseudoarthrosis [5–7], we decided to apply sternal plates also to the adolescent with massive sternal deformity.

Most important was the fact that remnants of sternal bone were still present on both sides, which is a requirement for complete chest stability. Only adaptation and fixation of the ribs is not possible because longitudinal stability otherwise cannot be ensured.

Another very important factor in the use of plates in the pediatric patient population is the timing of plate removal. On the one hand, the plates should be left in place long enough for complete healing and stabilization of the sternum, on the other hand, the plates could also restrict the development and the growth of the chest. For how long these plates should stay is unclear. We decided to perform a CT-scan after six months to assess the status of the sternum. The sternum showed good healing in the middle and distal part. In the proximal part a gap was still visible. In addition, two screws were loose. In this situation it was decided to remove the plates and we found the sternum to be in good condition and stable. Most surprisingly, we also found the proximal part, the manubrium included, to be in stable condition. The intraoperatively-applied synthetic material was completely healed, however, this was not visible in the X-ray. This clearly demonstrates that synthetic bone material can also bridge quite extensive gaps in the bone.

Regarding the plates, in this child we used standard materials which are made for adult patients. Therefore, the length of the plates might sometimes be suboptimal and the extensive bending of the plates for a perfect fit might be problematic.

The titanium plates are a great alternative for the correction of sternal deformities in children, as well as in adults. Even if the application in young patients is limited and not very frequently used, further modifications of
Fig. 2. (a,b) Installation of four titanium plates after setting the sternal halves in an anterior (a) and posterior (b) view. In the manubrium a gap between the bone pieces still visible (b, arrow). (c) Intraoperative position after plate installation which shows a good shaping of the sternum and plates. (d) Plate removal six months postoperatively. (e) Stable sternum in satisfying shape after complete plate removal.

the osteosynthesis system are possible which would optimize the application in general.

References


