Multidirectional Thoracic Wall Stabilization: A New Device on the Scene

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Purpose. **Stabilization and replacement of ribs is still a challenge, because most available systems for intramedullary and extramedullary fixation are less than perfect. We present our experience with a modified device, which compensates for several disadvantages in other methods.**

Description. **Originating from the Strasbourg Thoracic Osteosyntheses System (STRATOS [MedXpert GmbH, Heitersheim, Germany]), the multidirectional thoracic wall stabilization system uses tripodal clips with sharp clasping legs. They can be placed without dissecting the ribs, and bridge fractures or defects with titanium bars can be avoided. A rotating lug provides multidirectional stabilization.**

Evaluation. **We used the multidirectional thoracic wall stabilization system in 4 patients (thoracic deformity, Poland syndrome, flail chest, and thoracic wall hernia). Placement of the devices met with expectations on simplified handling. The long-term follow-up showed no displacement or fracture of the implants and an uncomplicated clinical course.**

Conclusions. **The newly designed multidirectional thoracic wall stabilization system provides multidirectional use and reduces surgical trauma. In the long term, this device could help to lower the threshold for surgical stabilization of flail chest, for example, and widens the spectrum of less-invasive reconstruction of chest wall deformities.**

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In thoracic surgery, stabilizing procedures of the chest wall remain challenging [1]. Indications range from fixation of dislocated rib fractures and flail chests, to reconstructing extended chest wall resections or remodeling of thoracic wall deformities [2, 3]. The main problem is, in contrast to any other osteosynthesis, the bony elements of the thoracic wall cannot be immobilized. Therefore, the risk of implant dislocation or material breakage is high, as is the development of pseudarthrosis. Additionally, appropriate placement of the surgical device still entails extensive surgical trauma.

Since the early 1970s, various systems for intramedullary and extramedullary stabilization of the ribs have appeared on the market, none of which was ideal or compensates for the disadvantages of the others. A recent innovation has emerged from Strasbourg, where J. M. Wihlm revitalized the principle of rib clips by developing the Strasbourg Thoracic Osteosyntheses System (STRATOS) system (MedXpert GmbH, Heitersheim, Germany) [4]. The advantage of this new device is the multimodal use in stabilizing reconstructed deformities and bridging of chest wall defects. The STRATOS system consists of differently angulated titanium rib clips that are connected by adjustable titanium bars, and initial reports on clinical application are encouraging [5–7]. However, our first clinical experience with STRATOS revealed the following limitations: placement of the clips requires an extensive surgical approach with dissection of the ribs; the clips are too big for use in younger or slim patients; and the clips cannot be clamped to short rib fragments, for example, close to the vertebral column.

Taking these limitations into consideration, the original STRATOS system was modified and put at our disposal. Together with our department of anatomy, we ran feasibility tests in thoraces of body donations to ensure that the new devices can safely be used for stabilization of ribs that are not dissected from periosteum and intercostal muscles.

Technology

The multidirectional thoracic wall stabilization (MTS) system is a derivative of the STRATOS system and

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combines existing elements with newly designed clips to broaden the field of application. In contrast to any other system, the tripodal MTS clips have sharp clasping legs, which allow placement without dissecting the ribs from the surrounding tissue. Until now, clips were only available in one single size, as prior research by the department of anatomy on configuration and dimensions of human ribs revealed that this particular standard clip will probably fit more than 90% of the patients. On the top of each clip is placed a rotation lug, which holds the titanium bar (Figs 1A, 1B).

The strategy of the operative procedure is determined by the individual indication. For example, to stabilize dislocated rib fractures, superficial exposure of the thoracic wall is sufficient. The sharp legs of the clips are pressed through the intercostal space and the clasps are shaped by the tripodal clasp bending plier. Movement of the plier from one side to the other allows for fitting of the sharp tips of the legs around the rib. The titanium bar is then pushed into the mobile lugs of the clips, and finally becomes fixed using the crimping plier. For patients with extended thoracic wall resection, bridging of the defect may also require vertical stabilization. In these cases, an additional bar connecter with one rotating lug is available (Fig 2).

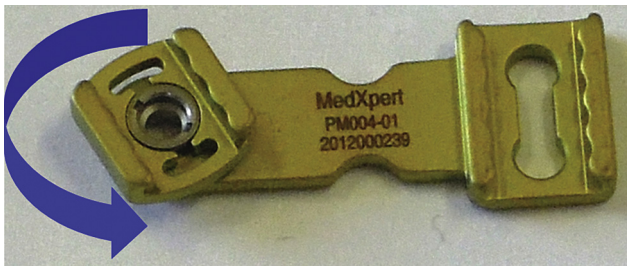

Fig 2. The additional bar connector has one rotating lug for vertical stabilization.

Technique and Clinical Experience

The Institutional Ethics Committee, which approved the prospective observational study (1758/2012), asked that each enrolled patient had to be informed in particular about the use of a modified system and to confirm his or her agreement by signing an informed consent form.

The first patient in our series was a 14-year-old boy who presented with a recurrence of a thorax deformity. Two years previously, the right costal arch had been lifted by mobilization of the eighth rib and implantation of a Vicryl (Ethicon, Somerville, NJ) mesh. The result of the previous procedure was unsatisfactory, and the patient insisted on further surgery. After osteotomy of the affected ribs, the costal arch was reconstructed using four clips and two bars of the MTS system. The postoperative course was uneventful and roentgenography control after 18 months showed neither dislocation nor breakage of the implants.

The second case, also a 14-year-old adolescent, was referred to our hospital 10 days after a car accident. He still had from a flail chest on the left, treated by placement of a chest tube and administration of high dosages of analgetics. A three-dimensional view by computer tomography revealed fractures of the left ribs 3 to 7, with fragments of the sixth and seventh rib that threatened to injure lung parenchyma (Fig 3A). Reduction and stabilization of two ribs with MTS clips and two bars was performed by open surgery. The chest tube was removed the next day and the patient was discharged on day 3 without analgetics. The further course was uneventful, and 17 months later, the implants were found to be in the same position (Fig 3B). The patient is free of any complaints and declines removal of the implants.

[ST]Anterior chest wall reconstruction was performed in a 17-year-old male patient with Poland syndrome. The patient presented with shortened left hypoplastic ribs 3 to 5 (Fig 4A), dysplasia of the costosternal portion of the pectoralis major muscle, and stricture due to severe axillary scarring. The first step in correcting this complex deformity of the thorax was to mobilize the left dysplastic ribs 3 and 5 and to resect bilaterally parasternal prominent rib cartilages. The costosternal defect of the upper chest wall was then bridged with two bars, which were fixed with MST clips on the left-hand side at the dysplastic ribs and contralaterally to the right of the

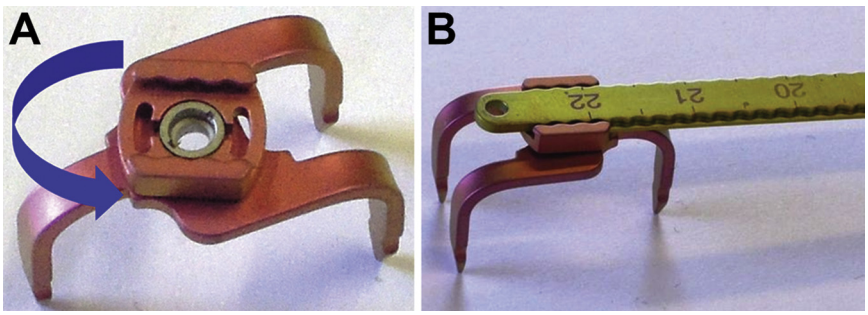

Fig 1. (A) The tripodal multidirectional thoracic wall stabilization (MTS) clip, with (B) rotation lug, which takes the titanium bar.

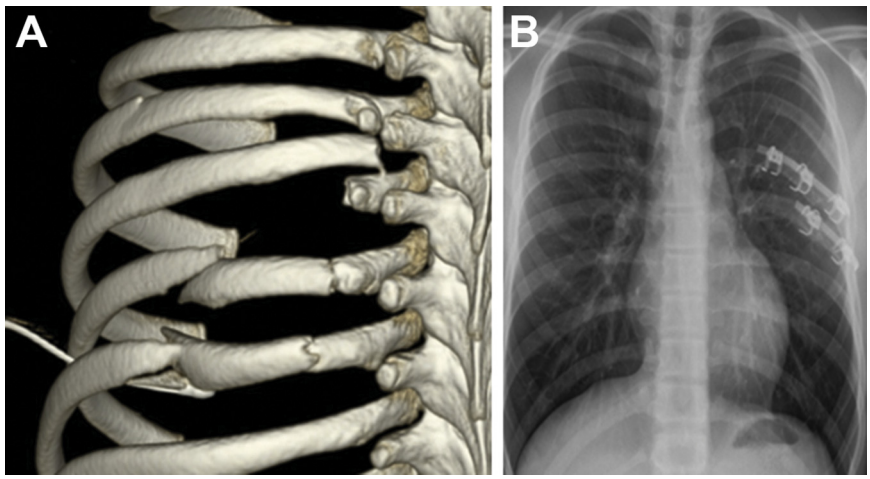

Fig 3. Left-sided flail chest. (A) Three-dimensional view by computed tomography reveals fractures of the left ribs 3 to 7. (B) Roentgenogram 17 months later shows the implants in correct position.

sternum. The remaining muscular defect was covered with a musculocutaneous flap of the left latissimus dorsi muscle. Finally, the skin stricture was corrected with consecutive Z-plasties. The postoperative course was uneventful. Two weeks after the procedure, the patient began physiotherapy and work on the newly positioned muscle. On follow-up, the patient stated his appreciation of the cosmetic and functional improvement and continues with physiotherapy. A roentgenogram of the thorax 9 months later showed that the implants were still in place (Fig 4B).

The fourth case in our preliminary series was a 67-year-old man presenting with a recurrent thoracic wall (intercostal) hernia due to chronic obstructive pulmonary disease and severe obesity; he had undergone surgery 2 years earlier with the implanting nonresorbable mesh. The computed tomography scan showed the hernia was localized between ribs 9 and 10 (Fig 5A). The second procedure was performed by open surgery using four MTS clips and two bars to close the intercostal defect (Fig 5B). The patient was discharged from hospital on the seventh postoperative day with a clinically satisfying result. A control roentgenogram 9 months later showed no displacement or material breakage of the implants.

Comment

Our first and preliminary series of the application of the MTS system confirmed the feasibility of thoracic osteosynthesis without extended dissection of the ribs. Placement of the newly designed clips is easy to perform and anticipated risks—for example, damage or irritation of the intercostal nerves and vessels, perforation of the parietal pleura, or laceration of the lung—did not occur. Although the follow-up period is relatively short, no dislocation or material break could be observed. All titanium implants are still in place, and the question as to whether they should be removed is still open.

In the meantime, we continue to use the MTS system for various indications, but the follow-up on these patients is too short to include them in this preliminary technical report. Nevertheless, our experience is predominantly encouraging and reconfirms the positive

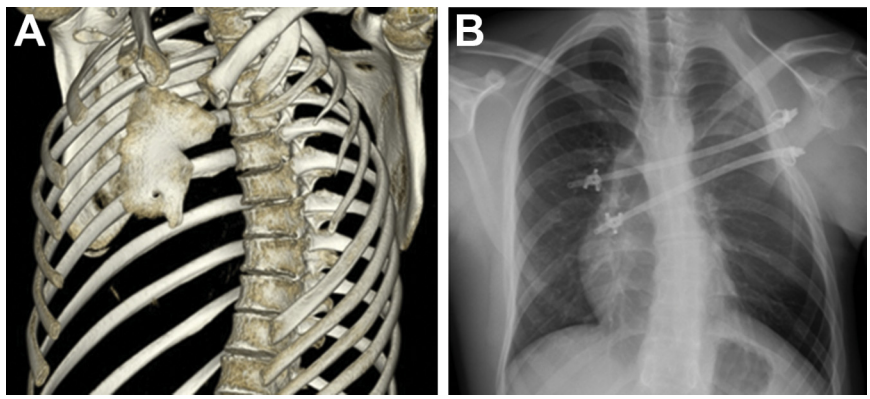

Fig 4. A 17-year-old male with Poland syndrome. (A) Three-dimensional view by computed tomography shows the hypoplastic ribs 3 to 5. (B) Roentgenogram of the thorax 9 months later shows the implants still in place.

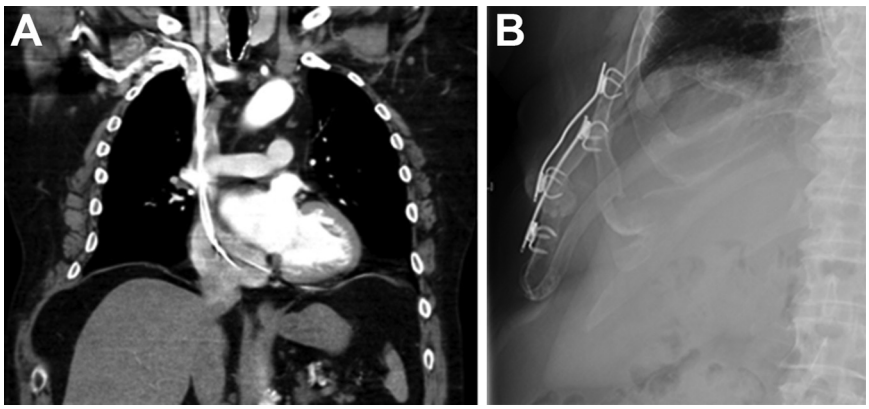

Fig 5. A 67-year-old man presenting with a recurrent thoracic wall (intercostal) hernia. (A) Computed tomography scan shows the hernia between ribs 9 and 10. (B) Roentgenogram control 9 months later shows the implants in correct position.

statements made. As yet, we still have not operated on patients with extended thoracic wall resections; therefore, we cannot comment on the option of additionally stabilizing a defect with vertically fixated bars.

In the near future, the system should be tested on a larger series, for example, trauma patients with flail chest or dislocated rib fractures. As another positive result of MTS is considerably reduced surgical trauma. In these cases, the clips could be placed with limited skin incision and reduced exposure of the fractured rib, while the connecting bar would be subcutaneously inserted before crimping it into the clip's lugs. That would be a less invasive approach to treating polytrauma patients with an unstable thorax, reducing the surgical trauma considerably and shortening ventilatory assistance time.

In conclusion, our first and preliminary experience with the MTS system is encouraging, and we will continue to use it separately or in combination with the already established STRATOS system.

Disclosures and Freedom of Investigation

Claus Petersen, MD, discloses a consultancy agreement with MedXpert, Eschbach, Germany. The company had no influence on the clinical application of the surgical devices. All other authors have nothing to disclose.

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