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THE CHEST WALL COMPANY

STRACOS

STRASBOURG
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OSTEOSYNTHESE

Thoracic Trauma HANDBOOK

Goals, Concepts and Technique

1st Edition

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SO EASY! SO STABLE!

Index

Intended Use 3

Treatment Goals 3

Treatment Concepts 3

When is the best time for a surgical stabilization of fractured ribs? 4

Is it mandatory to stabilize each fractured rib? 4

When and why 3D rib clips or implant bridges are used? 5

Approach to a fractured rib 6

Periosteum removal or preservation? 6

Repositioning of the fracture stumps and helpful instruments for that 7

The Neurovascular Bundle (NVB) 8

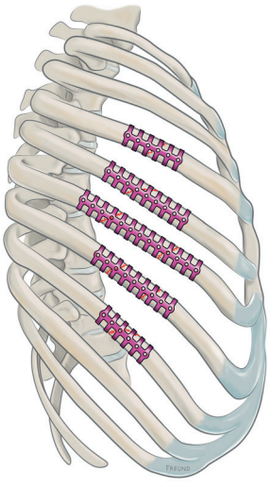
Is it possible to use 3D rib clips also in cartilage fractures?..... 8

Postoperatively 9

Removal of the implants 9

INTENDED USE

Surgical stabilization of single, multiple and comminuted fractures of the ribs, either immediately after trauma or secondary after failed conventional therapy.



TREATMENT GOALS

Blunt trauma of the chest wall does occur mostly in traffic accidents, deep falls, working accidents, house work or sports accidents as well as in physical violence. The patient suffers often from severe pain and, deliberately, avoids to breathing and coughing normally and also avoids body movements intensifying the pain. Thus, mostly a measurable impairment of the lung function develops which may lead to a life threatening pneumonia with often lethal end.
Therefore, the treatment goals are “pain management”, “lung physiotherapy” and stabilization of fractures thus leading to quick and complication free rehabilitation.

TREATMENT CONCEPTS

In principle, there are two treatment concepts:

1. Conservative therapy:

In extreme cases ventilation by positive pressure (intensive care stay), patients are sedated while the positive pressure supports “internal splinting” and stabilization of the chest cage.

Disadvantage: The disadvantages of this concept are well known. Long intensive care stay, often for several weeks, high risk for lung infections, prolonged hospital stay, slower rehabilitation and often a large number of work days lost due to illness, significantly restricted quality of life, late return to “normal life”.

Advantage: No surgical intervention.

2. Surgery:

Immediate stabilization of fractures by implants.

Advantage: Short or no intensive care stay and mechanical ventilation support, quick pain reduction, lower risk for infections, early discharge from the hospital, optimal rehabilitation and few number of work days lost due to illness, early return to normal life.

Disadvantage: Surgical intervention.

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WHEN IS THE BEST TIME FOR A SURGICAL STABILIZATION OF FRACTURED RIBS?

In principle the rule is: Stabilization as early as possible after the trauma.

However, there are a number of factors influencing the point of time for surgery, significantly:

1. In polytrauma patients life-threatening injuries are the first priority for treatment. Since chest wall trauma usually is not life-threatening, surgical treatment is mostly done secondarily. Primarily, the patients undergo intensive care therapy (ventilation) which may implicate that these patients receive surgical stabilization of the chest wall days or even weeks later or not at all because the advanced healing process during conventional therapy.

2. One of the few reasons for an immediate surgical intervention at the chest wall is not the stabilization of fractures as such but severe injury of vessels and inner organs avoiding a lethal outcome.

3. In cases of sole chest wall trauma the focus is the severity of pain, if the pain can be treated by standard pain management or not and if caused by pain and other soft tissue injuries normal breathing is impaired.

Diaphragm injuries, blood and air accumulations in the ribcage which impair proper lung function as well as lung contusions or lacerations are indications for early surgery.

Some of these soft tissue injuries are easily diagnosed by X-ray, CT and MRI, however, quite often smaller injuries are unrecognized and only by intraoperative thoracoscopic evaluation recognized and treated. In the first hours after chest wall trauma the patient is often only monitored to find out if pain, blood and air accumulations, lung contusions are progressive demanding an early intervention or if it is better to wait with surgery for a couple of days.

IS IT MANDATORY TO STABILIZE EACH FRACTURED RIB?

In principle, the answer is a „no“, provided the fracture stumps are properly reduced, reasonably stable and it is not a comminuted fracture. In practice quite often just 2 - 3 ribs are clipped in cases of 5 fractured ribs (either 1, 3, 5 or 2 and 4).

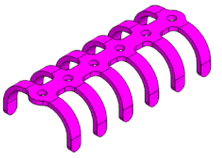
Though, there is the unpredictable risk that non-stabilized fractures may shift again postoperatively, the fracture stumps may rub at each other, etc. resulting in a secondary instability leading quite often to chronic pain and pseudarthrosis demanding a secondary intervention; at least the rehabilitation time is unnecessary prolonged. Aiming for the optimal stabilization of all fractures these risks should not be taken.

Therefore, in principle a “no”, however, to rule out uncontrollable risks, a clear “yes”.

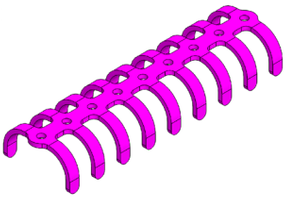
Treatment of rib 1 and 2: In practice ribs numbers 1 and 2 are not stabilized using rib clips because the additional soft tissue trauma caused including additional risks to damage important anatomical structures is unbalanced. In each individual case the risk and benefit must be assessed and a decision has to be made.

WHEN AND WHY 3D RIB CLIPS WITH 6, 9 OR 13 SEGMENTS AND IMPLANT BRIDGES?

The 3D rib clip with 6 segments is used in narrow spaces, provided the fracture line is relatively rectangular to the longitudinal axis of a rib and allows minimum 2, ideally 3 pairs of claws (segments) on either side of the fracture.

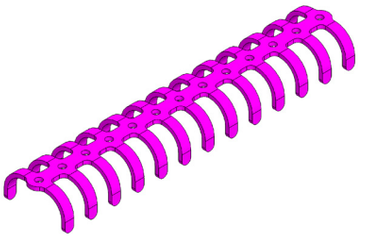


The 3D rib clip with 9 segments is the standard clip because the treatment of many slightly oblique fractures allows that at least 3 pairs of claws (segments) can be fixed laterally of the fracture.



Note: The more pairs of claws (segments) are positioned on either side of a fracture, the safer and more stable the fixation as such is.

The 3D rib clip with 13 segments is used in very oblique fractures, spiral and comminuted fractures.



The 3-D rib clips are available in two sizes:

- Standard with a width of 21 mm
- XL with a width of 25,5 mm for wide ribs

In comminuted fractures with a large central fragment two 3D rib clips in serie or one implant bridge may be used.

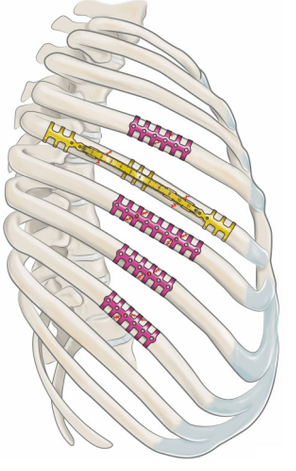


Illustration: Example of treatment of a serial rib fracture; single fractures and comminuted fracture; with 3D rib clips and one implant bridge with overarching fragment fixation consisting of three titanium rib clips and one titanium connecting bar.

Fundamental: No 3D rib clip shall be “shortened” by cutting off one or several segments.

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APPROACH TO A FRACTURED RIB

The surgical approach to a fractured rib is categorically done from above the rib along its longitudinal axis, the length of the incision depends on if just one or several ribs (rib serial fractures) must be treated. The definition of a rib serial fracture is at least 3 fractured ribs in a row. Often more than 3 ribs are injured which demands a longer incision since the muscles (Pectoralis major, Pectoralis minor, Serratus) stepwise have to be dissected sideways. If this is not possible (because the rib fracture is in the middle below a muscle) the muscle is split in the direction of the fibers to get access to the fractured rib until the periosteum layer of the rib is identified.

Example Anterior rib serial fracture involving ribs 3 to 8:

The skin incision follows the longitudinal axis of the middle rib (5); the length of the incision depends on the individual patient (skinny or obese). A wound spreader is inserted to keep the area open, the muscles are stepwise dissected or split as explained above. This creates a lance-shaped rhombic "window", wide above rib number 5 and tapered towards ribs 3 and 8.

The fractured ribs 4 to 7 are stabilized using 3D rib clips with 9 segments and, provided there is enough space, also ribs 3 and 8 are stabilized using 3D rib clips with 9 segments. However, very often the space given in the area of the fractured ribs 3 and 8 is too narrow for positioning 3D rib clips with 9 segments. Provided, the fracture lines are relatively rectangular to the longitudinal axis of the ribs, 3D rib clips with 6 segments are used for stabilization. Each fracture must being stabilized in a way that minimum 2, better 3 pairs of claws (segments) are attached on either side of a fracture. If the application of a 3D rib clip with 6 segments is impossible due to the direction of the fracture and/or limited space, additional dissections for widening the area are necessary.

Usually, the "middle" rib of a rib serial fracture receives the first 3D rib clip, followed by stepwise clip fixation up- and downwards.

PERIOSTEUM REMOVAL OR PRESERVATION?

Most of the pain comes from the periosteum of the rib which by movements during breathing and other movements is permanently unphysiologically moved and irritated; and secondarily from the surrounding traumatized tissues.

Periosteum consists of an outer collagen layer with elastic fibers and an inner layer with many cells which also includes nerves and blood vessels.

The cambium layer contains progenitor cells that develop into osteoblasts. These osteoblasts are responsible for bone growth and bone healing after fractures.

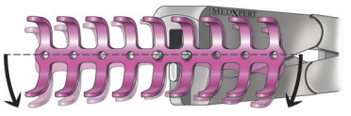
The periosteum is, in contrary to bone tissue as such, extremely sensible to pain. Furthermore, the periosteum serves for the nutrition of bone.

Therefore, the periosteum should, if possible, be left intact as good as possible. One constraining reason for partial periosteum removal is given if without this step the fracture can't being evaluated properly.

REPOSITIONING OF THE FRACTURE STUMPS AND HELPFUL INSTRUMENTS

Usually, repositioning and alignment of the rib stumps is succeeded manually and allows an assessment how a 3D rib clip must be bent to optimally match and be attached to the rib surface.

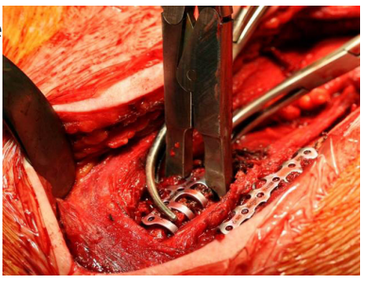
For the three-dimensional bending of a rib clip flat-nosed bending pliers and a three-point bending pliers are available for bending maneuvers up or down or laterally or twisting the implant in the longitudinal axis of the implant. These instruments are used cautiously and with sure instinct as otherwise the material is overstressed already in this step which may lead to implant failure.



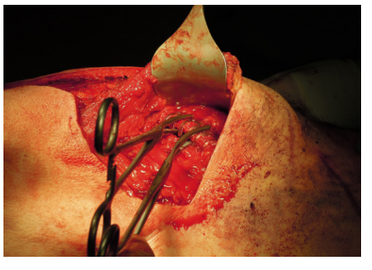
Bending a rib clip up- or downwards works often manually without using instruments and is, if possible, preferred because this allows the material "to flow" homogeneously during the bending process.

Multiple alternating back and forth bending maneuvers are strictly to be avoided since the cold-straining material would loose its elasticity to withstand many load changes which as well may lead to implant failure.

After having formed the 3D rib clip correctly, the implant is positioned over the fracture. Temporarily, and to avoid dislocation of the clip and the fractured site, standard forceps are used whereby basically two alternative options are considered:



1. Two straight dissecting forceps (Kocher, Pean or similar) are moved towards the upper border of the rib and being attached in a right angle to the longitudinal direction of the rib left and right of the fracture holding also the implant in position. After having closed at least two each rib clip segments on both sides of the fracture, the dissecting forceps are removed and the remaining clip segments are fixed.



2. Alternatively, an also approved method for temporary stabilization is to use a curved dissecting forceps (for example Mikulicz) which is attached longitudinal over the implant and fracture. To avoid any risk for the NVB the dissecting forceps is applied from above towards the upper border of the rib.

In both alternatives the instruments are stepwise moved to close all rib clip segments wherby the direction "towards the upper border of the rib" reduces the risk to catch and injure an intact NVB.

IMPORTANT NOTE

Before using for the first time, it is absolutely essential to read our „Application Manual" and our Instructions for Use. We always recommend intensive product training and briefing by MedXpert or an authorised specialist dealer prior to the first intervention using productsof this system.

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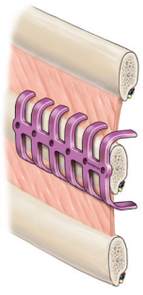
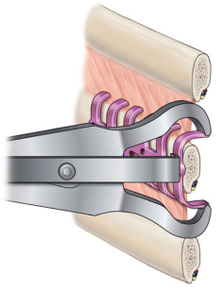
THE NEUROVASCULAR BUNDLE (NVB)



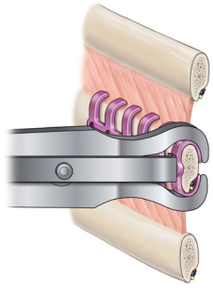
For anatomical reasons, injury of the neurovascular bundle during direct application of rib clips without deperiostation or dissection of the neurovascular bundle is unlikely.

The neurovascular bundle is not simply freely floating in the intercostal space. On the contrary, it is relatively well protected owing to anatomical features. The rib itself has not a simple rectangular shape on transsection, but the lower border on the reverse side of a rib determines a groove located behind a bony lip. The neurovascular bundle is situated in this groove in a way that the anterior/inferior border of the rib descends lower than the bundle itself and hence offers some protection.



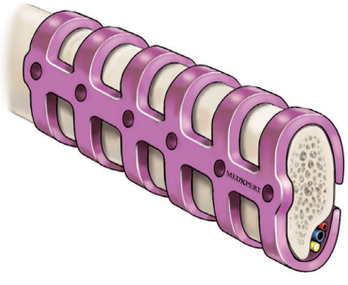
It is not mandatory to dissect the NVB, unless injuries of the NVB shall be ruled out or need to be treated.

If a rib clip is properly applied to a rib, the pairs of claws (segments) bend along the upper and lower border and close circular towards the posterior aspect of the rib. Maximal pressure and mechanic stress is exerted onto the edges of the upper and lower border. The upside claws, which are tightened against the upper border of the rib, are far away from the neurovascular bundle.



The downside claws embrace the lower border, which descends farther than the neurovascular groove; when they are modeled further to the posterior aspect of the rib, they eventually determine a ring which leaves some space around the neurovascular bundle.

IS IT POSSIBLE TO USE 3D RIB CLIPS ALSO IN CARTILAGE FRACTURES?



Rib cartilages are a quite soft tissue and often show fractures/dislocations after chest trauma, the main symptom is pain and chest wall instability.

Therefore, these fractures should be stabilized in the same way like the rib fractures. In cartilage fractures the same criteria as in rib fractures, related to the selection of rib clips and their positioning, are applied.

Our recomendation, when applying the clips, is to close them gently to prevent additional injuries of the cartilage.

POSTOPERATIVELY

When the patient needs chest drains these can be removed usually after 24 hours.

A subcutaneous chest drain should be kept in for 48 - 72 hours.

Depending on the injury pattern and the severity of the trauma patients stay in the hospital for 4 -7 days.

The patient is discharged from the hospital without specific behavioral rules; if pain emerges or is getting worse the relevant activity must be limited or stopped.

One week postoperatively wound staples can be removed, suture material after 10 - 14 days.

Control X-rays are taken either on the day the patient is discharged or within 2 weeks after surgery.

Within a few weeks, dependent on each individual patient and on the severity of the trauma, the patient returns to normal life.

Six months after surgery a final control evaluation including Chest X-rays is useful.

Implant removal 6 - 9 months postoperatively.

REMOVAL OF THE IMPLANTS

The rib clips are consisting of pure Titanium and are therefore bioinert. However, each implant is a foreign body and solely serves the purpose to support the healing process. After healing is completed the implant is no longer needed and the continuous physiological stress on an implant may cause fatigue of material and finally result in material breackage.

Since the rib clips are applied on the outer surface of the chest wall it is most unlikely that severe injuries may be caused by eventually later occurring material breakages, usually, the patients don't recognise implant breakage or sense just a transitorily negligible nuisance.

Of course it must be assessed if the damage caused by implant removal is well balanced and justified compared with the benefits.

The secondary intervention for implant removal is done under general anaesthesia with its known collateral risks, the surgical approach is carried out in a similar way as the implantation (if only few implants have been used a smaller incision is possible). Mostly, the implants are at least partially covered with bone and newly built bone is attached close to the implant segments. By means of a strong yet small and sharp periosteal elevator the overgrown bone is partly removed and an access below the implant is created, preferably underneath the segments located at the upper side of the rib. Stepwise the single segments are bent up with either the periosteal elevator or by means of a flat-nosed pliers until the implant is detached. Not infrequently, especially when implants are strongly overgrown with bone and virtually embedded, a small chisel is needed to create accesses underneath the implant for the use of the flat-nosed pliers.

In any event the question regarding implant removal must be explained by the surgeon and discussed with the patient. It is recommended to record the decision in writing.

Due to these reasons we recommend to remove all rib clips within 6 - 9 months, postoperatively. Finally, it is the surgeon upon consultation with the patient who takes the decision for or against implant removal.

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