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ORIGINAL ARTICLE

Evaluation of long-term results and quality of life in patients who underwent rib fixation with titanium devices after trauma

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Abstract
Objective To describe the long-term results, quality of life and chronic pain after chest wall fixation for traumatic rib fracture using a quality of life (QOL) score and a numeric pain score.
Methods Retrospective analysis of 10 consecutive patients who underwent surgery for rib fractures after trauma and reconstruction between October 2010 and March 2012. Chest rib fractures were fixed with titanium clips and bars or titanium plates and screws through a posterolateral thoracotomy. Pain was assessed with a numeric pain scale 0–10 and quality of life (QOL) with the EORTC questionnaire QLQ-C30.
Results There were 5 males and 5 females. The median age was 58 years (range 21–80). There were no postoperative deaths. The only postoperative complication observed was a contralateral pleural effusion requiring drainage. Median length of stay of the drain and median length of hospital stay were 2 days (range 0–8) and 4 days (range 1–42 days), respectively. The average follow-up period of operatively managed patients was 14 months (range 8–23.5 months). Seven patients scored the pain as 0, one as 1 (mild), one as 4 (moderate) and one as 8 (severe). Only two patients are taking occasionally pain killers. Only one patient presents severe limitation in his life scoring his QOL as poor.
Conclusions Titanium devices (clips and bars; screws and plates) are effective and safe for repair of rib fractures and showed good long-term results in terms of pain and quality of life after the operation.

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Introduction

Rib fixation for trauma remains controversial as isolated rib fractures often heal spontaneously. However, some patients with multiple rib fractures present with flail segments or have overlying rib fragments which cause severe pain, respiratory compromise and non-union [1]. In these cases, there is an increasing interest in rib fixation to improve the recovery of these patients.

The use of titanium bars, plates and screws has increased recently in the fixation of rib fractures. The Strasbourg thoracic osteosynthesis system, Stratos (MedXpert GmbH, Germany) is based on titanium clips and bars, and the vertical expandable prosthetic titanium rib system, Synthes (SYNTHES® Solothurn, Switzerland), is a system based on titanium plates and screws.

The evidence for rib fixation of flail segments is better established [2, 3]. Recent studies have reported on the benefit of rib fixation in reduction of pain [4, 5]. However, the evidence of long-term benefit and patient-reported quality of life (QOL) after rib fixation for fractures is limited. The aim of this study was to describe the long-term results, QOL and presence of chronic pain after chest wall fixation for traumatic rib fracture using a QOL score and a numeric pain score.

Materials and methods

This is a prospective series of 10 consecutive patients who underwent rib fixation with new titanium fixation system

(Stratos and Synthes) between October 2010 and March 2012. Patients were included if they had surgical fixation of multiple rib fractures with titanium devices caused by trauma and resulting in respiratory compromise, severe acute or chronic pain, with or without alteration of chest wall anatomy.

All patients had a chest CT scan with 3 dimensional reconstruction to ascertain the extent of the trauma. All patients had a full preoperative evaluation including a thorough history, physical examination and routine haematological and biochemical blood tests. Individual patient consent was obtained for each of the cases.

All operations were performed under general anaesthesia. All patients had an epidural catheter inserted. The surgical access was a posterolateral thoracotomy, the extension and the location varied according to the locations of the rib fractures. We avoided the use of accessory thoracotomies to minimise surgical trauma and pain. All the fractured ribs were stabilized, the pleural cavity was always opened to check for any bleeding and to remove the fluid or the clots. If no effusion was present on preoperative imaging or during operation, a small redivac drain was used. In case of effusion or lung injury, a 28Fr intercostal drain was inserted.

In one case, the patient had a contra lateral haemothorax without rib fractures on the side of the effusion; a contra lateral drain and thoracoscopy was performed to remove the clots to avoid any risk of empyema.

The titanium device in the Stratos system consists of clips that are crimped onto the edges of the fractured ribs using special pliers. It is very important that the clips are adherent for all their surfaces to the ribs. A connecting bar measured and cut to the length of the defect is then inserted only in case of ribs fractures in multiple points. The bars can be bent and moulded according to the thoracic shape.

The Synthes system consists of titanium screws and plates. The appropriately sized plate is selected during the operation such that there are at least two screws on either side of the fracture. Any excess callous is filed down or resected, and the periosteum is elevated before the plate is placed on the rib and secured with screws. To achieve adequate stability, the titanium devices are fixed on the ribs for at least 3–5 cm on either side of the defect or fracture. Both titanium systems can only work when attached to ribs and are, therefore, not suitable for posterior fractures involving the neck of the rib or the transverse process of the spine.

Surgery for rib fractures was undertaken after flail chest with failed weaning off the ventilator, failed conservative management with persistent pain, mobile rib fractures, alteration of normal anatomy of thoracic cavity, concomitant hemothorax, mal-union rib fracture and chronic instability. Patients who had rib fixation of single or 2 fractured ribs had persistent pain with mobile fragments causing crepitus and had been on Morphine for at least 3 months with little improvement in pain. They were, therefore, classified as failed conservative management.

In one case of rib fracture with malunion and a large anterior chest wall defect, we used a gore-tex patch (GORE-TEX® Soft Tissue Patch, W. L. Gore & Associates, Newark Delaware) due to the tension and absence of adequate muscular soft tissue coverage.

Individual patient data were obtained from case notes and operation notes as well as a prospectively collected surgical database. Continuous data are reported with medians and ranges, while categorical data are reported with counts and percentages. Chi square, Fisher test and student's t test were used as appropriate. Patient characteristics are reported in Table 1.

We obtained the approval of the local ethical committee of Guy's Hospital to follow-up and contact the patients undergone this procedure. We downloaded officially the QLQ-C30 score from the EORTC score asking for permission to use the score. Global health status, functional scale and symptom scale were analyzed and described; raw score was also reported and a linear transformation was

Table 1 Characteristics of the study population ($n = 10$)

Characteristic	Synthes ($n = 6$)	Stratos ($n = 4$)
Sex (M:F)	3:3	2:2
Age (years) [Median (range)]	56 (21–73)	75 (53–80)
Associated fractures	1	2
Side (R:L)	1:5	2:2
No. of fractured ribs [Median(range)]	3 (1–4)	6 (1–6)
Patients with 2–3 rib fractures	3	1
Patients with 4–6 rib fractures	1	2
Single rib fracture malunion	2	1
Site of rib fractures		
Anterior	1	0
Lateral	4	3
Posterior	1	1
Cranial	1	1
Caudal	5	3
Associated hemothorax	1	2
Median intraoperative blood loss ml	<100	<100
Operating time min [Median (range)]	92 (50–120)	83 (40–85)
Length of stay of the drain (days) [Median (range)]	2 (1–3)	2.5 (0–8)
Length of hospital stay (days) [Median (range)]	3.5 (1–11)	5.5 (4–42)
Follow-up (mo) [Median (range)]	10.8 (6–12.6)	17 (6–21)
Postoperative complication[a]	–	1

[a] controlateral reactive effusion which required a drainage insertion

used to standardise the raw sore. The score ranged from 0 to 100; a higher score showed a better level of functioning and a worse level of symptoms. Specifically to our analysis, we analyzed questions 1–12 and 29–30 [6].

Results

Between October 2010 and March 2012, a total of 10 patients (5 males, median age 58 years, range 21–80) underwent rib stabilisation for chest wall trauma and were included in this study. Four patients presented after a road traffic accident, three after a fall and three for pseudoarthrosis for an old trauma.

In three patients, rib fixation was undertaken after failed conservative management with persistent pain and mobile rib fractures (Fig. 1), in three patients for concomitant hemothorax (1,000, 400 and 400 ml), in three patients for mal-union rib fracture and chronic instability and in one patient with flail chest with failed weaning off the ventilator. Seven patients in total had rib fixation within 7 days of the original trauma and 3 had surgery for persistent pain at least 3 months from the time of the fracture.

Two patients had associated clavicular fractures and one had bilateral humerus fractures and left foot metatarsal fracture.

We used the Stratos system in four cases and in the remaining six the Synthes system. The intraoperative characteristics and the postoperative parameters are reported in Table 1. Only one patient had also a contralateral operation for a persistent hemothorax, at the time of the first operation to stabilize the left rib fractures a drain was inserted on the right to drain the hemothorax, 2 day after a right video assisted (VATS), hemothorax washout was performed for persistent basal collection on chest computed tomography. There was no postoperative mortality; only one patient experienced a contra lateral effusion which required a drain insertion. There was no statistical difference in terms of operating time, length of the drainage and length of the hospital stay between the two devices. All patients were discharged home after the operation; no one required long-term hospital stay for rehabilitation.

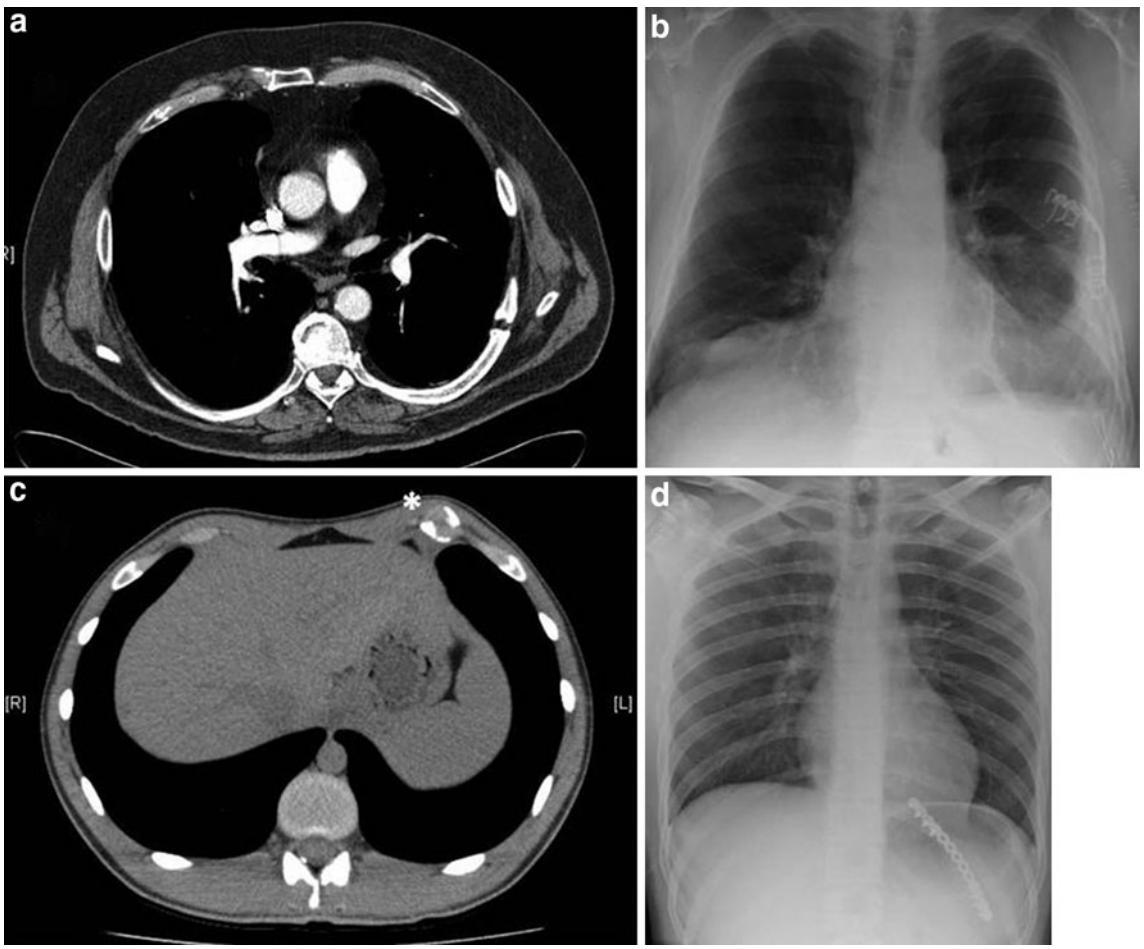

Fig. 1 **a** CT image showing a single malunion posterior rib fracture; **b** CXR showing the correct position of the device; **c** CT image showing an anterior malunion rib fracture (*asterisk*); and **d** CXR showing the postoperative results after a month

All patients were followed up in clinic and they were requested to fill in a questionnaire about their pain and about their QOL. The median follow-up period of operatively managed patients was 14 months (range 8–23.5 months).

Using the numeric pain scale 0–10 and QOL with the EORTC questionnaire QLQ-C30 for assessment postoperatively, patients in the Synthes group reported that their residual pain had interfered with their life quite a lot in 1 patient, a little bit in 2 and not at all in 3. In the Stratos group, one patient reported that pain had interfered a lot with his life and a little bit in another one. The remaining 2 patients in this group reported no interference in their life from pain. The median pain score rating was 0 (range 0–8). Now at the last follow-up, seven patients rated their pain 0: 5 in the Synthes group and 2 in the Stratos group; one patient rated the pain 1 (mild), one patient 4 (moderate) in the Synthes group and only one patient 8 (severe) in the Stratos group. Only the two patients with moderate and severe pain are taking pain killers (Cocodamol or Dihydrocodeine). The patient with the severe pain suffers from diabetes mellitus as well, which may contribute to his neuropathic pain.

Of these 10 patients, 9 were satisfied with the results of the operation, only one did not find any improvement after the operation. In the Synthes group, 5 patients returned to their normal activities in 2 months time after the operation, except one who is a soldier and has still some limitations in his physical activity; 5 patients reported an excellent QOL following the rib fixation and only one, who still suffers from moderate pain, rated his QOL as good. In the Stratos group, two reported a poor QOL and are not back yet to their normal life activity, one a very good QOL and only one an excellent QOL. Of the two patients with poor QOL, one of them had a poor QOL also before surgery according to his rating of his QOL before surgery. The median QOL and general health score according to the QLQ-C30 in the Stratos group were 4.5 (range 2–7) and 4 (2–7, respectively), and 7 (range 6–7) and 7 (range 6–7) in the Synthes group. There is a statistical difference in the two groups in terms of QOL and general health ($p = 0.04$).

Analyzing the specific physical activities affected by the operation using the questionnaire, three patients reported a lot of limitations in vigorous activities, two in the Stratos group and only one in the Synthes group. Asking specifically about working activities, lifting and walking, in the group of Synthes only one complained in mild limitations in these activities; in the Stratos group, one reported severe limitations and two mild limitations in these activities. In the Stratos group, analyzing the functional scales and a symptom scale, median values of 53.5 (range 20–100) and 39.5 (range 0–100) were found, respectively. In the Synthes group, analyzing the functional scales and a symptom scale, median values of 93 (range 70–93) and 2.35 (range 0–33) were found, respectively. According to the linear transformation, the value of 93 in the functional scale indicated a higher ("better") level of functioning and the value of 39.5 in the symptom scales indicated a higher ("worse") level of symptoms. There is no statistical difference between functional scale ($p = 0.1$) and symptom scale ($p = 0.08$) in the two groups.

Discussion

Interest in rib fixation for traumatic rib fractures has waxed and waned over the years. Controversy remains as to the indications of surgical fixation of rib fractures. The benefits of surgical fixation of flail segments reported by Tanaka et al. in a randomised control trail include significant reduction in the number of days requiring mechanical ventilation, number of days in the ICU and rates of pneumonia between the surgical and non-surgical groups. They also found a difference in the rate of return to work at 6 months and the total cost of care [2]. Similar results were reported by Granetzny et al. [3] in another randomised trial. We had only 1 patient with a flail segment in whom surgical fixation facilitated weaning off the ventilator.

Other indications of rib fractures fixation include acute, severe intractable pain with significantly displaced rib fracture segments, significant chest wall deformity and persistent and chronic pain which affects normal life [7, 8]. The benefits of rib fracture fixation in terms of pain relief as assessed by analgesic requirements have been reported by de Moya et al. [4]. Patients undergoing rib fixation had a significant reduction in Morphine requirements after surgery. There are no specific guidelines in the literature on indications for fixation of rib fractures. However, reports in the literature note that there is an increased risk of death and significant morbidity (longer duration of ventilation, ICU and hospital stay) with each additional rib fracture, especially in the elderly (>65 years) [9]. In the setting of acute fractures, early fixation is associated with good outcomes and significant improvement in pain [10]. This is especially so in cases where there are 3 or more fractures with cortical overriding [10]. We found similar results in the 7 cases that we operated on acutely (within 7 days of fracture). These patients had improvement in pain and in the case of flail chest, weaning off the ventilator was facilitated.

Rib fixation for chronically fractured ribs is indicated for persistent pain caused by delayed fracture union with point tenderness over the site of the previous fracture, even if there is only one single rib fracture. This is especially so if the pain affects the patient's QOL (for instance interfering with work) [10].

Two studies have reported on long-term morbidity, pain relief and QOL after surgical rib fixation for fractures. Mayberry et al. reported the morbidity and patient-reported pain score in 15 patients as assessed by questionnaire at a mean follow-up of 22.3 months after the surgery. The mean pain rating using a McGill Pain Questionnaire was 6.7 indicating fairly significant residual pain [7]. Although we used a different pain score, most patients in our study had no residual pain with a shorter follow-up. We, however, had a smaller proportion of patients with other associated injuries and our patients had less severe chest injuries.

Analyzing the EORTC QLQ-C30 data, we found that the QOL and general health were significantly higher in the Synthes group. The raw score analysis showed that the functional scale and symptom scale values were clinically worse in the Stratos group compared to the Synthes group but with no statistical difference.

Half the patients in our study returned to their normal activities within 2 months of surgery. Another half rated their QOL as excellent at the time of follow-up. This compares with published results. In their study on QOL after rib fixation at a median follow-up of 34 months, Campbell et al. reported that 55 % of patients reported being able to perform all activities they did before the chest trauma. Mean return to work and normal activities in their study was 3.9 months. This compares with 2 months in our cohort. Patient satisfaction with the results of surgery was 100 % in the study Campbell et al. [11] and 90 % in our cohort.

In our limited experience patients undergoing rib fixations did not show any postoperative complications and most of them reported an excellent recovery. Only one patient is not satisfied with the results of surgery.

We believe this is a safe technique that can improve the QOL of patients with multiple rib fractures or single, malunited fractures with chronic pain.

This is only a small preliminary report with a good follow-up. The number of patients is too small to show significant advantages and draw conclusions. Further multi-institutional prospective trials are needed to better assess the advantages of rib fixation after trauma.

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Conflict of interest None declared.

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