Long-term outcomes of surgical rib fixation in patients with flail chest and multiple rib fractures

Kenichiro Uchida, Masahiro Miyashita, Shinichiro Kaga, Tomohiro Noda, Tetsuro Nishimura, Hiromasa Yamamoto, Yasunitsu Mizobata

ABSTRACT

Background  Recently, interest has increased in surgical fixation for severe thoracic wall injury with good short-term outcomes. However, few reports have evaluated long-term outcomes or complications. This study aimed to assess long-term quality of life and implant-related complications after rib fixation for flail chest and multiple rib fractures.

Methods  We interviewed patients who had undergone rib fixation from January 2014 to December 2019 about their current ability to work and their usual life.

Results  Twenty-two patients underwent rib fixation during the study period. Two patients with flail chest had already died after the surgery due to senescence; thus, follow-up information was obtained from 20 patients (91%), with a follow-up duration of 47.5 (IQR 22–58) months. The most undesirable event occurring during the study period was irritation caused by a palpable plate (n=2, 10%), probably due to the thin skin of patients over 70 years old. Eighteen patients were able to return to their usual life or same work as in the premorbid state with no complaints. Two patients are still undergoing rehabilitation due to concomitant extremities fractures. The median EQ-5D-5L index score was 0.89 (IQR 0.84–0.93). There were no implant-related complications requiring plate explantation.

Discussion  We concluded that rib fixation offers good long-term benefits, with the ability of the patient with flail chest or multiple rib fractures to return to activity in the premorbid state. Elderly patients especially with thin, soft tissue may complain of irritation caused by the plate and should be informed of this prior to surgery.

Level of evidence  Level IV therapeutic care/management.

BACKGROUND

Flail chest and multiple rib fractures are one of the most commonly occurring injuries especially in blunt trauma, and their influences on mortality, and morbidity are not negligible. As previously reported, up to 60% of patients experienced some kind of morbidity, such as nosocomial pneumonia, prolonged respiratory instability, prolonged number of ventilation days, and a resulting long-term hospital stay.1 2 Recently, open reduction and internal fixation of critical rib fractures have been performed globally with good short-term outcomes.3 5 Previous reports including one meta-analysis comparing the outcomes of surgical rib fixation with conservative therapy for critical thoracic wall injury reported the advantages of rib fixation not only in decreasing mortality and the incidence of pneumonia or tracheostomy but also in shortening the hospital and intensive care unit (ICU) length of stay.3 5

However, the long-term outcomes focusing on delayed complications and patient quality of life after rib fixation are still not well elucidated. Some previous studies described the sufficient effectiveness of surgical rib fixation, but their follow-up rate was only about 50% and follow-up duration was approximately within 1 year.1 6 Therefore, the purpose of this study was to assess the exact long-term patient quality of life and implant-related complications after recent surgical rib fixation for both flail chest and multiple rib fractures.

PATIENTS AND METHODS

Treatment strategies for patients with flail chest and multiple rib fractures

This study was performed at the Department of Trauma and Critical Care Center of Osaka City University Hospital. Because there is no universal definition for multiple rib fractures, we defined the term to be fractures of at least more than two ribs either unilaterally or bilaterally. Following the strategies for multiple rib fractures in our institution, if the patients had a flail segment at their injury site, they were intubated, and operative fixation was the priority for repair of the segment. For patients who did not have flail segments, we preferred to perform surgical rib fixation for massive fractured rib dislocations, such as ribs lacerating the lung (figure 1A) or when overlapping of the fractured ribs was >15 mm (figure 1B) on the basis of CT scan, the patients could not be tapered from continuous intravenous or epidural narcotics, or the patients could not start rehabilitation due to the severe pain caused by the fractured ribs. Patients who died from severe brain, abdominal, spinal, or pelvic injury as indicated by an Abbreviated Injury Scale (AIS) score of >5 were excluded. We also excluded patients with severe brain injury who had not recovered during hospital admission, as indicated by not attaining a Glasgow Coma Scale score of >8, and those with spinal or pelvic injury for which a lateral decubitus position for surgery was difficult or contraindicated.

Surgical strategy for patients with flail chest and multiple rib fractures

The operations were performed under general anesthesia and differential lung ventilation. Surgical access to the fractured ribs was via posterolateral muscle-sparing or minimal thoracotomy, and
depending on the number of fractures to be repaired, several types of skin incisions were performed. In all cases, the three or four most dislocated or flailed segment ribs were fixed by locking screws and plates (Synthes, Oberdorf, Switzerland). After fixation, a 28 Fr intercostal drainage tube and 10 Fr subcutaneous drainage tube were inserted. We consider that if the patients have criteria for surgical rib fixation, the surgery should be performed within 7 days after admission because delayed surgical fixation becomes more difficult and results in longer operating time compared with surgery performed in the early phase following injury.

Survey and evaluation of quality of life of patients

To assess long-term outcomes including patients’ current ability in daily life, current working status and quality of life, we performed a telephone survey with the patients or their families depending on the number of fractures to be repaired, several types of skin incisions were performed. In all cases, the three or four most dislocated or flailed segment ribs were fixed by locking screws and plates (Synthes, Oberdorf, Switzerland). After fixation, a 28 Fr intercostal drainage tube and 10 Fr subcutaneous drainage tube were inserted. We consider that if the patients have criteria for surgical rib fixation, the surgery should be performed within 7 days after admission because delayed surgical fixation becomes more difficult and results in longer operating time compared with surgery performed in the early phase following injury.

Figure 1  Indications for surgical rib fixation. (A) Massive fractured rib dislocations, such as ribs lacerating the lung. (B) Overlapping of fractured ribs of >15 mm.

Figure 2  Flow chart of patient inclusion in the study. Of the 326 patients diagnosed as having multiple rib fractures, 79 potentially had an indication for rib fixation. However, 57 patients were excluded, and the remaining 22 patients underwent surgical rib fixation. Two patients had already died due to senescence. Finally, we could contact and obtain follow-up information from 20 patients. GCS, Glasgow Coma Scale.
performed worldwide in major trauma centers, and the reported
months.
2020; 5
Surgical rib fixation is currently
In the previous decade, the treatment options for flail chest
DISCUSSION
The long-term outcomes and observed events are described in
table 4. The median follow-up duration was 47.5 (IQR 22–58)
months. The most undesirable event occurring during the study
period was irritation caused by a palpable plate (n=2, 10%),
probably due to the thin skin of patients over 70 years old.
Eighteen (90%) patients were able to return to their usual life or same
work as in the premorbid state with no complaints. Two (10%) patients
are still undergoing rehabilitation due to concomitant
extremities fractures. The median EQ-5D-5L index score was
0.89 (IQR 0.84–0.93). There were no implant-related complications
requiring plate explantation.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Description of the fractured ribs</th>
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<tbody>
<tr>
<td>N=20</td>
<td></td>
</tr>
<tr>
<td>Number of fractured ribs</td>
<td>8 (6–10)</td>
</tr>
<tr>
<td>Site of rib fracture (including duplicates)</td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>11</td>
</tr>
<tr>
<td>Lateral/posterior</td>
<td>8/3</td>
</tr>
<tr>
<td>Number of fractured ribs consisting of flail segments</td>
<td>3 (2–5)</td>
</tr>
<tr>
<td>Maximum overlap of fractured ribs (mm)</td>
<td>18 (15–22)</td>
</tr>
<tr>
<td>Data are presented as median (25%–75% IQR).</td>
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</tbody>
</table>

and 6 (3–10) days, respectively. Three (15%) patients with
concomitant pneumonia required antibiotics during hospital-
ization, and one (5%) patient with a medical history of severe
chronic obstructive pulmonary disease required a tracheostomy.
We also observed acute-phase partial plate detachment within
1 week in one patient (5%), who initially had extensive flail chest
concomitant with open pneumothorax on the anterior compo-
ments. This patient was also complicated with osteomyelitis but
was treated successfully with antibiotics and negative pressure
wound therapy (5%) (table 3).

The long-term outcomes and observed events are described in
table 4. The median follow-up duration was 47.5 (IQR 22–58)
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period was irritation caused by a palpable plate (n=2, 10%),
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<table>
<thead>
<tr>
<th>Table 3</th>
<th>Short-term overall outcomes</th>
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<tbody>
<tr>
<td>N=20</td>
<td></td>
</tr>
<tr>
<td>Total duration of IMV (days)</td>
<td>4 (1–8)</td>
</tr>
<tr>
<td>Total duration of ICU stay (days)</td>
<td>6 (3–10)</td>
</tr>
<tr>
<td>Pneumonia onset during admission</td>
<td>3 (15%)</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>1 (5%)</td>
</tr>
<tr>
<td>Implant-related infection</td>
<td>1 (5%)</td>
</tr>
<tr>
<td>Failed extubation</td>
<td>1 (5%)</td>
</tr>
<tr>
<td>Implant migration/detachment</td>
<td>1 (5%)</td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td>0</td>
</tr>
<tr>
<td>Statistical data are presented as median (25%–75% IQR) or number (%).</td>
<td></td>
</tr>
</tbody>
</table>

incidence of complications such as pneumonia or tracheostomy
are decreased.6 12 Second, it is easy to terminate the administra-
tion of continuous intravenous or epidural analgesic drugs such as
fentanyl,12 13 which also contributes to helping the patient start
rehabilitation smoothly. Third, by performing rib fixation, we
can shorten the number of days of mechanical ventilation, which
contributes to shortening of length of hospital and ICU stays.14 15

With regard to perioperative unexpected events, we observed
one patient with acute-phase partial plate detachment within
1 week. This patient had extensive flail chest including thin ante-
crior costal cartilage and sternum components. Hence, we had to
use short unlocking-screw for fixing the plate. However, from
this experience, we routinely use longer-sized locking-screw
even for fixing anterior thin segment.

Currently, there are few studies evaluating the long-term
outcomes or complications of patients undergoing rib fixation,
although some studies have described the long-term assess-
ment of factors such as irritation or quality of life of these patients.8 9 16–18
Importantly, these past studies have small sample sizes,
their follow-up rates are limited to only about 50% of the
patients, and the follow-up duration is within several months up
to 1 year.

Beks et al8 reported as long-term results that 48% of their
patients had implant-related irritation and 9% required implant
removal. In the present study, irritation was also reported by
some patients, but the incidence rate was approximately 10%
among the patients followed up. We can offer no explanation
for the large difference in the incidence rates of this compi-
lcation between these studies. However, in our study, the two
patients complaining of irritation were both aged over 70 years
old, and thus we consider irritation to be one of the risks in
elderly patients. Currently, none of our patients requires implant
removal.

The EQ-5D-5L index is used globally to evaluate the quality
of life of patients8 9 19 20 and includes the best components to
evaluate patients’ general health condition. The patients who under-
went surgical rib fixation in our study had scores almost equal to
the average score of the standard EQ-5D-5L index in Japanese
aged 60 to 69 years (male: 0.911, female: 0.899).11

Caragounis et al20 reported that 45 patients with rib fixation
for flail chest and multiple rib fractures had an EQ-5D index
score of 0.93 after 1 year of follow-up. In another study, Campbell
et al17 described slightly lower quality of life after 1 year of
follow-up following surgical rib fixation. We think this is
possibly because their included patients had more severe trauma
as indicated by their higher ISS.

As described, the EQ-5D-5L index is a score for evaluating
general health conditions and not specifically thorax-related
problems. We used this index because we were unable to eval-
uate the complaints of the patients objectively and directly.


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However, almost all of the patients indicated that they were adequately satisfied with rib fixation in the long-term follow-up period. There were no implant-related deaths in our patients or complications requiring additional procedures during the observational period.

Although the number of patients in this study is small, it has one of the highest follow-up rates and also one of the longest follow-up durations of the published studies. Previously, we reported that surgical rib fixation is a safe and effective strategy for obtaining good short-term outcomes both for patients with flail chest and those with multiple rib fractures. In this study, the long-term outcome, which was assessed by comparing the EQ-5D-5L index score with that of a Japanese reference population, showed no decrease in the score and patient satisfaction was adequate. Prior to surgery, it is important to inform patients, especially the elderly patients, that about 10% of them may experience irritation from the rib plating.

Limitations
Although the present study is a small preliminary report with good follow-up, it is a single-center study, and the number of patients is too small to establish significance and conclusive proof of long-term benefits of surgical rib fixation. Further multi-institutional, prospective, randomized trials will be needed to assess the long-term outcomes of surgical rib fixation and its complications.

CONCLUSIONS
We conclude that in patients with flail chest or multiple rib fractures, rib fixation offers good long-term benefits for return to their premorbid state. Older patients, especially those with thin, soft tissue, may complain of irritation caused by the rib plate and should be informed of this prior to surgery.

Contributors
KU and YM designed this study and also conducted the literature search. Ton contributed to the literature search, data analysis, study design, critical revision, and writing of the article. KU and MM contributed to data collection and data interpretation. TN contributed to the literature search, data interpretation and critical revision. SK and HY contributed to study design and critical revision. All authors read and approved the final article.

Funding
The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests
None declared.

Patient consent for publication
Not required.

Ethics approval
As this was a retrospective study with no additional interventions, the Institutional Review Board of Osaka City University waived the need for ethical approval for this study

Provenance and peer review
Not commissioned; externally peer reviewed.

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