

Original article

Evaluation of Chrisofix® Chest Orthosis Application in Patients with Traumatic Rib Fractures

Ayşe Gökce Işıklı¹, Fazlı Yanık², Yekta Altemur Karamustafaoglu³, Yener Yörük⁴

Abstract:

Background: The Chrisofix® Chest Orthosis is an effective and easy to use device for the treatment of rib fractures. It is used as a supportive treatment to reduce the pain levels and complication risks of the patients. **Methods:** Patients hospitalized with the diagnosis of rib fractures in the Thoracic Surgery Service of a university hospital were retrospectively scanned in an online computer program between October 2018 and October 2021. The study sample consisted of patients with the treatment (30) and control (30) groups. **Results:** Visual Analog Scale and incidence of atelectasis of the patients in the experimental group (The Chrisofix® Chest Orthosis) is statistically significantly lower than the control group ($P < 0.05$). In both the experimental and control groups, no statistically significant difference was found between the variables of patient's demographic and clinical characteristics ($p > 0.05$). **Conclusions:** In the study, with the use of The Chrisofix® Chest Orthosis, a significant decrease was observed in the Visual Analog Scale and the incidence of atelectasis.

Keywords: Rib fracture; Chest,orthosis; Trauma

*Bangladesh Journal of Medical Science Vol. 23 No. 01 January'24 Page : 83-88
DOI: <https://doi.org/10.3329/bjms.v23i1.70689>*

Introduction:

It occurs when the body comes into direct contact with an acute energy source due to trauma, traffic accidents and falls.^{1,2} Due to trauma, serious injuries occur in important organs such as liver, spleen, pancreas and chest (such as lung).³ Thoracic traumas constitute one-third of patients hospitalized due to trauma, and it is indicated that approximately 20-25% of deaths occur due to thoracic traumas.^{4,5} Since thoracic traumas affect respiratory physiology, especially oxygenation, they can cause complications in all body systems and are generally observed with other system injuries. It is stated that rib fractures mostly occur due to blunt thoracic traumas.^{4,6} Thoracic wall

injuries can significantly increase morbidity and mortality rates due to the proximity of the thoracic cage to the cardiopulmonary system.^{7,8} The number of rib fractures is also known as an indicator of the severity of the trauma.⁶ The incidence of pulmonary contusion in rib fractures is reported as 17%.⁵

Rib fractures destabilize the chest wall, causing pleuritic and chest wall pain. This results in decreased respiratory volume and pulmonary complications.⁹

The incidence of rib fractures ranges from 10% to 26% in thoracic trauma, and the number of rib fractures determines morbidity and mortality rates.¹⁰ Severe pulmonary distress may cause breathing-dependent pain in which IV opioids are often inadequate in

1. Ayşe Gökce Işıklı, raky University, Health Research and Application Center, Edirne, Turkey, E-mail: ayysegokce@hotmail.com
2. Fazlı Yanık, Department of Thoracic Surgery, Trakya University Faculty of Medicine, Edirne, Turkey, E-mail: fazliyanik@trakya.edu.tr
3. Yekta Altemur Karamustafaoglu, Department of Thoracic Surgery, Trakya University Faculty of Medicine, Edirne, Turkey, E-mail: akaramustafaoglu@trakya.edu.tr
4. Yener Yörük, Department of Thoracic Surgery, Trakya University Faculty of Medicine, Edirne, Turkey, E-mail: yyoruk@trakya.edu.tr

Correspondence: Ayşe Gökce Işıklı, PhD, RN, Department: Thoracic Surgical, Institute/University/Hospital: Health Research and Application Center, Trakya University, Street Name & Number: -, City, State, Postal code, Country: Edirne, 2230, Turkey, E-mail: ayysegokce@hotmail.com, ORCID: 0000-0003-3785-1020

addressing pain and associated respiratory failure.¹¹ Especially, inadequate pain control despite numerous pain relief methods, such as paravertebral block, epidural block, IV continuous analgesia, and intercostal nerve block, may cause to postoperative pulmonary morbidities, such as secretion stasis, hypoxia, atelectasis, and pneumonia, by reducing respiratory and diaphragmatic function.¹²

In patients with rib fractures, external methods such as lidocaine patch 5%, transdermal opioids, and Chrisofix® Chest Orthosis (CCO) are also used to reduce pain and accompanying complications.^{13,14}

It is thought that CCO contributes to stabilizing the thoracic wall and reduces the complication index, especially in rib fractures in the anterior region. Furthermore, it has similar impacts in multiple rib fractures, such as flail chest. It is also thought to reduce pain by decreasing the rubbing of broken ribs against each other. Our study aimed to assess the possible contribution of CCO to the treatment and reduction of complications in patients with traumatic rib fractures.

Method and Material:

A retrospective randomized controlled analysis of sixty patients with >3 ribs fractures between October 2018 and October 2021. The patients were divided into two groups according to whether CCO was applied or not. All patients received standart transdermal remifentanyl 25 mg and oral paracetamol 500 mg 4x1 as analgesics. Inclusion criteria were as follows: patients aged 18 years and over, patients with ≥ 3 rib fractures after blunt thoracic traumas.

Exclusion criteria were as follows: patients aged less than 18 years; pregnant women, patients undergoing emergency surgery; patients with a history of chronic pain; patients with < 3 rib fractures patients, unable to comprehend the evaluation instruments used Visual Analogue Scale (VAS), patients with additional bone fractures other than rib fracture, patients who underwent tube thoracostomy and patients who refused to participate in the study were excluded from the study.

Data Collection Tools

Patient's demographic and clinical characteristics form

This form consisted of 10 questions regarding age, gender, educational background, smoking, number of fractures, mobilization, length of hospital stay, patient level of pain, analgesic related adverse events

and complications associated with rib fractures.

Materials

CCO (Figure 1) was used in experimental group patients.

Intervention and Procedure

This review was carried out in an online computer program. The patients were divided into 2 groups as 30 experimental and 30 control patients. In addition to routine treatment and care, 30 patients who received CCO were assigned to the experimental group and 30 patients who received routine treatment and care was assigned to the control group. The "Patients demographic and clinical characteristics form," prepared in line with the literature^{10,13,15} was filled in retrospectively.

Application and adjusting:

Before sticking the splint to the thorax, the hairs and the skin must be cleaned .

- Set the marked plane of the splint to the thorax .
- Remove the sheet marked with from the splint plane.
- Use the splint to the injury region. The splint must cover the injured region.
- Remove the sheet from the bottom of the foil and press, using the flop on the outer surface of the splint remove the outhere see through foil (Figure 2).

The Chrisofix® Chest orthosis is lightweight, comfortable and non-radiopaque. Made of non-allergenic material. It must only be bent and never be cut. The chest orthosis should not be used for more than 10 days. Patients can take a shower using waterproof tapes.

Statistical Analysis:

Descriptive statistics were used in comparisons of demographic and clinical characteristics between the groups, while Mann-Whitney U test was used to compare Visual Analog Scale (VAS) values. Statistical analyses were performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA) with p value <0.05 accepted as statistically significant.

Ethical Clearance:

In order to perform the study, the necessary written permissions were taken from the Trakya University School of Medicine Scientific Research Ethics Board (TÜTF-BAEK 2022/159: decision number 08/23)

and the Health Research and Application Centre's Central Directorate. Written and verbal consent was obtained from the patient for the painting (Figure 2). Patients' information was collected from institutional database

Results:

The distribution of the descriptive statistical data is presented in Table 1. In both the experimental and control groups, no statistically significant difference was found between the variables of age, gender, educational background, smoking, number of fractures, mobilization, and length of hospital stay ($p > 0.05$) (Table 1). The VAS of the patients in the experimental group is statistically significantly lower than the control group ($P < 0.05$) (Table 2). The incidence of atelectasis in the experimental group patients was statistically significantly lower than the control group ($P < 0.05$) Other analgesic related adverse events and complications associated with rib fractures between groups are not statistically significant (Table 3).

The atelectasis that developed was resolved with flexible bronchoscopy (in six cases 6 cases) and nasotracheal aspiration in two cases. Antiemetic agents were used in all patients for nausea and vomiting. Crystalloid fluid support was administered in patients who developed hypotension, and 0.5 mg of atropine were administered in patients who developed bradycardia. Patients who develop pneumonia were treated with intravenous (IV) ampicillin sulbactam 4x1.5 gr according to fever, C reactive protein (CRP) and radiological response.

Discussion:

In 2017, the Chest Wall Injury Society published a consensus statement regarding the overall management of patients with rib fractures, emphasizing an organised respiratory physiotherapy¹⁵. The guideline supported by the Association for the Surgery of Trauma recommends a multimodal approach instead of epidural analgesia or opioids alone in patients with rib fractures.^{8,16}

Rib fractures are cases that usually heal without treatment, and patients are treated symptomatically in these cases. Pain control is the main goal of treatment in patients with rib fractures. In the present study, CCO was used in addition to routine treatment and interventions in the experimental group.

In rib fractures, pain occurs due to the release of substances such as serotonin, bradykinin, and

prostaglandin, causing pain from the traumatized tissue, the decreased threshold of peripheral pain receptors, and the pleural irritation and inflammation of the broken ends^{7,17}. Epidural catheters, intercostal, paravertebral or pleural blocks, non-steroidal anti-inflammatory drugs (NSAIDs), and opioids constitute the main group of analgesics administered in rib fractures.^{5,9} Transdermal remifentanyl 25 mg and oral paracetamol 500 mg 4x1 were given to both groups as analgesics.

In the literature, it is recommended to use pharmacological and non-pharmacological methods together in pain management. Pain control is more successful when non-pharmacological methods are used to supplement pharmacological methods. In our study, we used CCO as a non-pharmacological method:

The study revealed that the VAS scores decreased statistically significantly in the experimental group patients in whom CCO was used compared to the control group ($P < 0.05$). In their studies, Mészáros et al.¹⁷ and Zsiros et al.¹⁸ also determined that CCO use significantly reduced pain and increased vital capacity. Pain reduction is essential in patients with rib fractures since it is stated to have a significant impact on the prognosis of patients because of pulmonary complications due to hypoventilation resulting from pleuritic pain.⁹ Additionally, the decrease in the pain score will reduce the use of opioid analgesics, and the development of complications that may occur due to the use of opioids will decrease.¹⁹ Numerous studies on rib fractures have investigated invasive or non-invasive treatment methods. In their study, Nirula and Mayberry²⁰ stated that surgical fixation methods of rib fractures might effectively reduce pain but might increase the risk of iatrogenic bleeding or pulmonary complications. No complications were observed in the use of CCO.

In the study, atelectasis was observed in fewer patients in the experimental group, and it was revealed to be statistically significant compared to the control group ($P < 0.05$). CCO stabilized the fractured rib area, reducing the level of pain and supporting more effective breathing and coughing exercises. In their study, Cobanoglu and Yalcinkaya⁷ determined that atelectasis (4.4%) was observed due to rib fractures. Chest pain caused by rib fractures leads to the restriction of coughing, inability to remove secretions, decreased functional residual capacity, and ultimately to the development of pulmonary atelectasis. This cycle causes hypoxia in patients,

thus increasing mortality.^{9,20-22}

The basic principle of the treatment of rib fractures is pain control and the prevention of possible complications^{4,9}. Moreover, using the correct pain relief methods, it is aimed to remove secretions easily, increase compliance with respiratory physiotherapy, provide early mobilization, reduce the incidence of complications, increase the quality of life, reduce the occurrence of chronic pain syndrome, accelerate the discharge process and thus reduce the cost.¹⁵ In our study, the use of CCO significantly reduced the level of pain and the rate of atelectasis.

Although no statistical difference was found between the two groups in the length of hospital stay in our study, Mészáros et al.¹⁷ reported that the use of chest orthosis could significantly reduce the length of hospital stay in patients with rib fractures. They also argued that a significant reduction in hospital stay costs could be achieved owing to the application. Unlike that, we think that, owing to the CCO application, it may be possible to get rid of hospital-associated infections, time and economic losses in addition to all the aforementioned contributions.

Limitation of the study:

We discovered some limitations in the course of our study. First, and the most important is the retrospective study design. Secondly, our findings are from a single institution and from a small number of case sample. Despite these limitations, the possible contributions of the application between the two groups could be evaluated. The current study provides valuable information about the contributions of CCO application in the treatment of rib fracture. Although there are limited studies on the subject in the literature, our study mainly describes that the application can be successfully and safely used in the future for rib fractures.

Conclusions:

In the study, a significant decrease was observed in the VAS score and the incidence of atelectasis with the use of CCO. In addition to other analgesic methods and, the use of CCO can be used safely and successfully in the treatment of traumatic rib fracture. By using CCO in the management of costal fractures, it should be aimed to evolve the respiratory functions and life quality of patients as soon as possible.

Authorship

A.G.I. conceived the study, analyzed the data, and wrote the paper. F.Y. created the final database from the various databanks and contributed to the analyses. Y.A.K. designed the study and contributed to the data analysis and writing of the paper. Y.Y. revised the paper.

Conflict of interest:

Authors has no conflict of interest to declare.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Table 1. Patients demographic and clinical characteristics

Patients n	Group 1 (n=30)	Group 2 (n=30)	P value
Age, years	58,4 ± 16,17	56,80 ± 15,98	0,325
Sex n (%)			
Female	3 (10)	7 (23,3)	0,514
Male	27 (90)	23 (76,7)	
Smoking n (%)			
Yes	16(53,33)	17 (56,66)	0,816
No	14 (47,77)	13(44,44)	0,761
Level of education n,%			
Literate	1 (3,3)	1 (3,3)	0,171
Primary school	23 (76,7)	23 (76,7)	
Secondary-High school	3 (10)	4 (13,3)	
University	3 (10)	2 (6,7)	
Number of fractures n (%)	4,46 ± 1,40	3,7 ± 1,7	0,214
Mobilization n (%)			
Good	10 (33)	11 (36,7)	0,741
Modarate	17 (57)	15 (50)	0,611
Bad	3 (10)	4 (13,3)	0,219
Length of hospital stay n, %	3,2 ± 1,09	4,16 ± 1,2	0,241

Group 1: Chrisofix® Chest Orthosis Group; Group 2: Control group; *P < 0.05, Values are mean ± standard deviation, n (%), number (percent), ASA: American Society of Anaesthesiologists.

Table 2. The comparison of visual analog scale scores (0 cm = no pain, 10 cm = worst pain imaginable) in both groups.

Time (hours)	Visual Analogue Scale		Group 1 vs. Group 2 (P)	The comparison intragroup of postoperative 1 (P)	The comparison intragroup of postoperative 2 (P)
	Group 1 (n=30)	Group 2 (n=30)			
0	6,26 ± 1,57	5,66 ± 1,93	0,031 ^a	< 0.0001 ^b	< 0.0001 ^c
1	4,13 ± 1,83	5,06 ± 1,76	0,026 ^a	< 0.0001 ^b	< 0.0001 ^c
7*	3,06 ± 1,77	5,16 ± 1,28	0,004 ^a	< 0.0001 ^b	< 0.0001 ^c
24	3,23 ± 1,77	4,5 ± 1,22	0,012 ^a	< 0.0001 ^b	< 0.0001 ^c
48*	2,86 ± 1,59	4,66 ± 1,17	0,001 ^a	< 0.0001 ^b	< 0.0001 ^c

Group 1: Chrisifix® Chest Orthosis Group;
 Group 2: Control group; Values mean ± standard deviation, ^aComparison between groups, P < 0.05
^bComparison to basal value in Group 1, P < 0.05
^cComparison to basal value in Group 2, P < 0.05
 * Statistically significant

Table 3. The comparison of analgesic related adverse events and complications associated with rib fractures between groups.

Patients n (%)	Group 1 (n=30)	Group 2 (n=30)	P value
Atelectasis	2 (12)	6 (20)	0,04*
Nausea and vomiting	3 (10)	4 (13)	0,296
Hypotension	2 (6)	3 (10)	0,596
Bradycardia	1(3)	2 (6)	0,369
Pneumonia	1(3)	2 (6)	0,671

Group 1: Chrisifix® Chest Orthosis Group; Group 2: Control group; *P < 0.05, n (%), number (percent), Hypotension episode: fall in systolic blood pressure more than 25% of baseline value for a period of less than 15 minutes
 Bradycardia episode: Fall in radial pulse more than 50/min for a period of less than 15 minutes

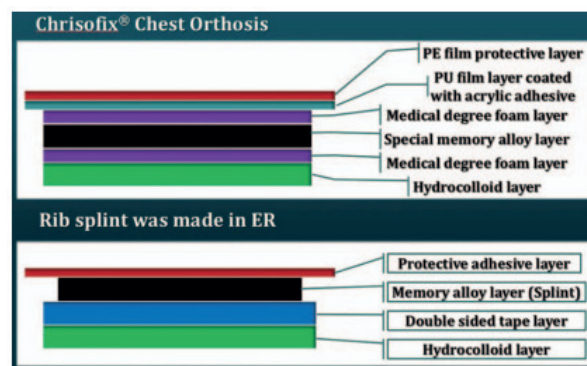


Figure 1. Chrisifix® Chest Orthosis (Lee et. al)

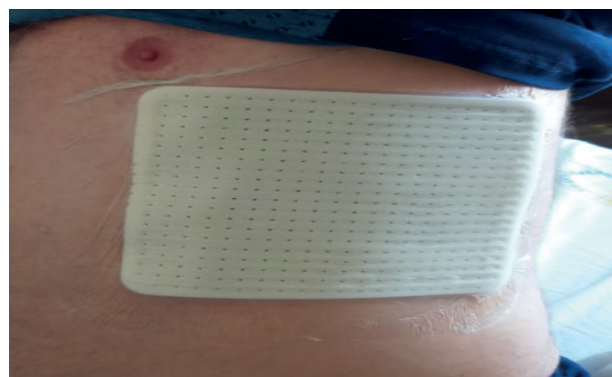


Figure 2. Patient treated with , Chrisifix® Chest Orthosis* (* Verbal and written consent was obtained from the patient.)

References:

- W Ahmad WMA, Noor NFM, Shaari R, Roslan NAN, Mustapa NH, Adnan MN, Ghazali FMM, Yaqoob MA, Akbar NAN, Aleng NA, Alam MK. A Five-Year Retrospective Study on Fractured Orbital Walls: A Spearman Correlation Analysis. *Bangladesh J. Med. Sci.* 2022;**21**(4):744–750. <https://doi.org/10.3329/bjms.v21i4.61362>
- Das S, Rashid MM., Hasanuzzaman M, Sarker AC,
- Ansari A, Ghosh D, Bhuiyan S. Surgical Outcome of EDH in Children: Our Observation in DMCH. *Bangladesh J. Med. Sci.* 2022;**21**(4):865–874. <https://doi.org/10.3329/bjms.v21i4.60288>
- Omar M M, Sönmez RE, Hassan MY, Alimoğlu O. Prevalence of war victims in Madina Hospital Mogadishu Somalia. *Bangladesh J. Med. Sci.* 2020;**19**(3):401–403. <https://doi.org/10.3329/bjms.v19i3.45855>.
- Acipayam A, Turut H. Chest injury to emergency

- department of applications time and trauma patients with type of relationship between morbidity and mortality. *KSU Medical Journal* 2021;**16**: 53-58. doi:10.17517/ksutfd.708522.
5. Coughlin TA, Ng JW, Rollins KE, Forward DP, Ollivere BJ. Management of rib fractures in traumatic flail chest: a meta-analysis of randomised controlled trials. *Bone Joint J.* 2016;**98**:1119-25. doi: 10.1302/0301-620X.98B8.37282. PMID: 27482027.
 6. Peek J, Smeeing DPJ, Hietbrink F, Houwert RM, Marsman M, de Jong MB. Comparison of analgesic interventions for traumatic rib fractures: a systematic review and meta-analysis. *Eur J Trauma Emerg Surg.* 2019;**45**:597-622. doi:10.1007/s00068-018-0918-7.
 7. Cobanoglu U, Yalcinkaya I. Thoracic injuries. *Turkish Journal of Trauma & Emergency Surgery.* 2010;**16**:77-83. <https://dx.doi.org/>.
 8. Witt CE, Bulger EM. Comprehensive approach to the management of the patient with multiple rib fractures: a review and introduction of a bundled rib fracture management protocol. *Trauma Surg Acute Care Open.* 2017;**2**(1):e000064. doi: 10.1136/tsaco-2016-000064. PMID: 29766081; PMCID: PMC5877894.
 9. Lee Y, Lee SH, Kim C, Choi HJ. Comparison of the effectiveness in pain reduction and pulmonary function between a rib splint constructed in the ER and a manufactured rib splint. *Medicine (Baltimore).* 2018;**97**:10779. doi: 10.1097/MD.00000000000010779. PMID: 29794759; PMCID: PMC6393019.
 10. Flagel BT, Luchette FA, Reed RL, Esposito TJ, Davis KA, Santaniello JM, Gamelli RL. Half-a-dozen ribs: the breakpoint for mortality. *Surgery.* 2005;**138**(4):717-23; discussion 723-5. doi: 10.1016/j.surg.2005.07.022. PMID: 16269301.
 11. Gibbons J, James O and Quail A. Management of 130 cases of chest injury with respiratory failure. *Br J Anaesth.* 1973;**45**(11):1130-5. doi: 10.1093/bja/45.11.1130. PMID: 4786998.
 12. Ballantyne JC, Carr DB, deFerranti S, Suarez T, Lau J, Chalmers TC, Angelillo IF, Mosteller F. The comparative effects of postoperative analgesic therapies on pulmonary outcome: cumulative meta-analyses of randomized, controlled trials. *Anesth Analg.* 1998 Mar;**86**(3):598-612. doi: 10.1097/0000539-199803000-00032. PMID: 9495424.
 13. Zink KA, Mayberry JC, Peck EG, Schreiber MA. Lidocaine patches reduce pain in trauma patients with rib fractures. *Am Surg.* 2011;**77**:438-42. doi: 10.1177/000313481107700419. PMID: 21679552.
 14. Ingalls NK, Horton ZA, Bettendorf M, Frye I, Rodriguez C. Randomized, double-blind, placebo-controlled trial using lidocaine patch 5% in traumatic rib fractures. *J Am Coll Surg.* 2010;**210**:205-9. doi: 10.1016/j.jamcollsurg.2009.10.020. Epub 2009 Dec 24. PMID: 20113941.
 15. Krdzalic G, Musanovic N, Krdzalic A, Mehmedagic I, Kesetovic A. Opiate analgesia treatment reduced early inflammatory response after severe chest injuries. *Med Arch.* 2016;**70**:457-459. doi:10.5455/medarh.2016.70.457-459.
 16. Galvagno SM Jr, Smith CE, Varon AJ, Hasenboehler EA, Sultan S, Shaefer G, To KB, Fox AD, Alley DE, Ditillo M, Joseph BA, Robinson BR, Haut ER. Pain management for blunt thoracic trauma: A joint practice management guideline from the Eastern Association for the Surgery of Trauma and Trauma Anesthesiology Society. *J Trauma Acute Care Surg.* 2016;**81**:936-951. doi: 10.1097/TA.0000000000001209. PMID: 27533913.
 17. Mészáros T, Sárváry A, Petri A, Záborszky Z, Bolla K. Use of chest orthosis can significantly shorten the hospitalisation of rib fracture patients. *7th European Trauma Congress. Ljubljana, Slovenia, May 14-17, 2006*;279-82.
 18. Zsiros L, Zaborszky Z, Petri A, Gergely Z, Bolla K. Easy and effective method for the treatment of rib fracture by using Chrisofix- technique. Proceeding of the 7th. *European Trauma Congress*; Code: G514C0347.
 19. Machelska H, Celik MÖ. Advances in achieving opioid analgesia without side effects. *Front. Pharmacol.* 2018;**9**:1388. doi: 10.3389/fphar.2018.01388.
 20. Nirula R, Mayberry JC. Rib fracture fixation: controversies and technical challenges. *Am Surg.* 2010 Aug;**76**(8):793-802. PMID: 20726406.
 21. Tignanelli CJ, Rix A, Napolitano LM, Hemmila MR, Ma S, Kummerfeld E. Association between adherence to evidence-based practices for treatment of patients with traumatic rib fractures and mortality rates among US Trauma Centers. *JAMA Netw Open.* 2020;**3**:201316. doi:10.1001/jamanetworkopen.2020.1316.
 22. Sum SK, Peng YC, Yin SY, Huang PF, Wang YC, Chen TP, Tung HH, Yeh CH. Using an incentive spirometer reduces pulmonary complications in patients with traumatic rib fractures: a randomized controlled trial. *Trials.* 2019;**20**(1):797. doi: 10.1186/s13063-019-3943-x. PMID: 31888765; PMCID: PMC6937666.