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The Effectiveness of Kinesiotaping for Patients with Fractured Ribs: A Single-subject Experimental Design

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Abstract

Purpose: Kinesiotape is an elastic, adhesive tape applied to the skin that has been used extensively to reduce pain associated with various musculoskeletal conditions. Its use in the setting of fractured ribs is less clear. The aim of this preliminary study was to investigate the effect of kinesiotaping for patients with rib fracture(s) on pain levels, pulmonary function, and mobility. Method: We prospectively evaluated five patients admitted with fractured ribs using a single-subject experimental ABAB design. Each phase lasted 24 hours with kinesiotape applied during B phases. All participants received usual medical, nursing, and allied health care. Outcome measures included pain levels (participant-rated), pulmonary function, and maximum mobility. The occurrence of skin irritation was tracked. Results: Considerable variability was seen between- and within-participants for pain levels. There was some evidence, albeit inconsistent, that pain levels were lower when the kinesiotape was in situ compared to when it was not. Pulmonary function and mobility levels showed no consistent pattern between intervention phases. Skin irritation occurred in one participant and another required escalation of medical therapy for pneumonia. Conclusions: Kinesiotaping may reduce pain for patients with fractured ribs but further research, preferably randomized controlled trials with homogenous samples and standardized medication regimens, is required to confirm its effectiveness in the acute care setting.

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ABSTRACT
Purpose: Kinesiotape is an elastic, adhesive tape applied to the skin that has been used extensively to reduce pain associated with various musculoskeletal conditions. Its use in the setting of fractured ribs is less clear. The aim of this preliminary study was to investigate the effect of kinesiotaping for patients with rib fracture(s) on pain levels, pulmonary function, and mobility. **Method**: We prospectively evaluated five patients admitted with fractured ribs using a single-subject experimental ABAB design. Each phase lasted 24 hours with kinesiotape applied during B phases. All participants received usual medical, nursing, and allied health care. Outcome measures included pain levels (participant-rated), pulmonary function, and maximum mobility. The occurrence of skin irritation was tracked. **Results**: Considerable variability was seen between and within participants for pain levels. There was some evidence, albeit inconsistent, that pain levels were lower when the kinesiotape was in situ compared to when it was not. Pulmonary function and mobility levels showed no consistent pattern between intervention phases. Skin irritation occurred in one participant and another required escalation of medical therapy for pneumonia. **Conclusions**: Kinesiotaping may reduce pain for patients with fractured ribs but further research, preferably randomized controlled trials with homogenous samples and standardized medication regimens, is required to confirm its effectiveness in the acute care setting.

Keywords: rib fractures, musculoskeletal pain, pain management, kinesiotape, athletic taping

INTRODUCTION

Rib fractures are a common injury particularly after blunt chest trauma and can result from car/motorbike/bicycle accidents, falls, assault, athletic activities, severe coughing, cardiopulmonary resuscitation, and metastatic rib lesions. Patients with fractured ribs experience considerable chest wall pain which impairs their ability to take deep breaths, cough, and mobilize.[1,2] Management of patients hospitalized with fractured ribs includes medications to reduce pain, using modalities including thoracic epidural, regional anesthetic blocks, patient-controlled intravenous medication and/or oral analgesics, anti-inflammatory drugs, and physiotherapy to optimize pulmonary function and encourage mobility.[1,2] Despite these interventions, patients with fractured ribs often experience break-through pain that adversely affects their pulmonary function and ability to mobilize.[1,2] Due to significant pain, these patients are at high risk of developing pulmonary complications such as atelectasis, respiratory tract infection, and ultimately respiratory failure, particularly in the setting of pre-existing respiratory disease and other co-morbidities.[1,2]

In the first half of the 20th century, semi-rigid strapping of the chest wall was often used for people with fractured ribs to splint and immobilize the area and thus reduce pain.[3-6] However, over time this practice, particularly strapping that encircled the rib cage, was questioned and eventually abandoned as rigid immobilization of the chest wall had the propensity to result in insufficient aeration of the underlying lung with an increased risk of lung infection and pneumonia.[4-6] As distinct from the semi-rigid strapping which restricts movement used in the past, kinesiotaping refers to the application of an elastic, adhesive, cotton-based tape onto the skin that was developed in the 1970s. Kinesiotaping is most often used in the management of musculoskeletal injuries such as patellofemoral pain, whiplash, and shoulder impingement syndrome.[7] Kinesiotaping differs from conventional adhesive taping or strapping due to its elasticity, which means it can be stretched longitudinally and therefore support soft tissues and joints without restricting underlying movement. In the setting of fractured ribs, both semi-rigid strapping and kinesiotaping have the common aim of splinting and supporting the affected area and reducing pain. Theoretically, in contrast to semi-rigid strapping, the elastic nature of kinesiotape should not rigidly immobilize the area nor impair pulmonary function. To date, the effectiveness of kinesiotaping has predominantly been investigated in musculoskeletal-related conditions, where, as summarized in a systematic literature review and meta-analysis by Montalvo et al, it may provide benefits in terms of reduced pain in individuals with musculoskeletal conditions, although this reduction may not be clinically important.[7]

The mechanism of action by which kinesiotaping may work is not well understood and may involve both ascending and descending neurological pathways.[7,8] Two studies have investigated the effectiveness of kinesiotaping in the setting of fractured ribs.[8,9] Czyzewski et al found, for 14 in-patients with "one or few" broken ribs, that kinesiotaping significantly reduced pain levels while deep breathing, coughing, and changing body position from supine to sitting within 15 minutes of application.[8] Sareen et al, in a study that involved 10 adult patients with 1-2 undisplaced fractured middle ribs, found that kinesiotaping significantly reduced patient-reported rib fracture pain during deep breathing or coughing.[9]

The usual practice for patients with fractured ribs admitted to our healthcare center has not included the use of any taping techniques, but two recent requests by medical staff for the application of kinesiotape raised our interest in its use. Therefore, the purpose of this preliminary study was to investigate the effect of kinesiotaping for patients with rib fracture(s) on pain levels, pulmonary function, and mobility while monitoring for the complication of skin irritation.

METHODS

Design

This pilot study utilized a single-subject ABAB design. The study was approved by the Central Adelaide Local Health Network Human Research Ethics Committee and registered with the Australian New Zealand Clinical Trials Registry.

Setting and Participants

The study was conducted at the Royal Adelaide Hospital, an 800-bed, tertiary-care, urban, public hospital in Australia from January to May 2018. Participants were adults (aged ≥ 18 years) admitted under the care of the Royal Adelaide Hospital Trauma Service with acute (< 48 hours) rib fracture(s). Exclusion criteria were intubation and mechanical ventilation, presence of other major medical conditions/injuries that could affect the biomechanics of the rib cage and/or application of the kinesiotape (e.g. underwater sealed drain, spinal injury or fracture, soft tissue injury of the chest wall), previous skin condition in the affected area that could be exacerbated by taping (e.g. psoriasis), previous allergy to tape, and an inability to communicate effectively and easily in English (e.g. insufficient understanding of English, head injury, cognitive impairment, psychiatric condition). We also excluded patients admitted under the care of one particular trauma surgeon who, because of concerns about the potentially detrimental effects of kinesiotaping, was unwilling for his patients to participate.

Methods

An investigator approached potential participants regarding participation from 0800 hours on day of admission. A written information sheet explaining the aims and format of the study was supplied and informed written consent obtained, with the study

period commencing later that same morning. Apart from the kinesiotaping, no other aspect of medical, nursing, or allied health care was changed.

The study interventions were provided using an ABAB design, where A = baseline phase (i.e., kinesiotape off) and B = intervention phase (i.e., kinesiotape on). Each phase lasted 24 hours, resulting in a total study intervention duration of 4 days. During B phases, kinesiotape was applied by one of two investigators between 0800 and 1000 hours and removed 24 hours later. To guide tape application, the location of the rib fracture(s) was confirmed by review of the chest x-ray and/or computed tomography (CT) scan and the participant indicating their area of greatest pain. Both investigators had previous experience with taping techniques and for this study referred to descriptions by Sareen et al and advice from physiotherapy colleagues, including internet resources.[9,10]

A length of kinesiotape (50mm width) was initially applied over the area of the fractured rib(s), with ~ 50% tension, and the tape extended anteriorly and posteriorly along the margins of the involved ribs (0% tension), with repeated lengths of tape applied as required to support the fractured rib(s).[9] After completion of the 4-day intervention period, participants were given the option of keeping the kinesiotape in situ or removing it, with their choice recorded.

A training session was held before the study commencement to ensure standardization of testing. The main outcome measure was participant-reported pain levels, measured using a verbal analog scale (VAS, where 0 = no pain and 10 = worst pain imaginable). Pain was measured at rest, during deep breathing and coughing, and while moving from supine to sitting on two occasions during each study phase – the first time between 2-4 hours post-application of kinesiotape in B phases and the second time between 4-8 hours post-application of kinesiotape in B phases. In addition, the least and greatest pain in the previous phase (i.e., 24 hours) were measured the next morning between 0800 and 1000 before the transition into the next phase of the study.

Secondary outcomes included pulmonary function and maximum mobility. Forced vital capacity (FVC) was utilized to measure pulmonary function. Following the early VAS pain score being provided by the participant, FVC was recorded as the best of three attempts on an EasyOne® spirometer. Participants' maximum mobility over each previous 24-hour period was recorded by an investigator at the first morning visit using the 0-10 ICU mobility scale (where 0 = nothing, lying in bed and 10 = walking independently without a gait aid). The 0-10 ICU mobility scale has been shown to be a feasible tool with strong inter-rater reliability for measuring maximum mobility in an ICU setting.[11]

The occurrence of any skin irritation/discomfort resulting from the kinesiotaping was documented at the end of each 24-hour period using a VAS (where 0 = no skin irritation and 10 = worst skin irritation imaginable) by the participant and one of the two investigators. If any major skin irritation (VAS ≥ 5) from kinesiotaping occurred, no further taping was done. After the study (day 5), participants were asked to rate the usefulness of the kinesiotaping (VAS, where 0 = no use and 10 = maximum usefulness imaginable). Participants' medical records were reviewed by an investigator at every visit to ascertain the occurrence of any respiratory complications (e.g. respiratory infection, lobar collapse, sputum retention) or escalation of respiratory support (e.g. higher level of supplemental oxygen, need for non-invasive or invasive mechanical ventilation).

Basic demographic and descriptive data were recorded for each participant including sex, age, past medical history, primary diagnosis, time post-injury, number/location/displacement of rib fractures and management thereof, analgesia, other injuries/conditions, and hospital length of stay.

Data Analyses

Given the single-subject study design, individual data are primarily reported and visually analyzed using figures. No statistical analyses were undertaken.

RESULTS

Study Participants

Five participants were recruited, with their baseline demographics and clinical data shown in Table 1. All participants fractured their ribs as a result of blunt trauma and all rib fractures were diagnosed using a combination of x-ray and CT findings. Three of the 5 participants (no. 1, 2 and 4) had no displacement of their rib fractures, with minimal displacement seen for the other 2 participants (no. 3 and 5). One participant (no. 4) was discharged from hospital on the morning of day 4 so had no outcomes measured thereon. Figure 1 shows the kinesiotaping in situ for one participant.

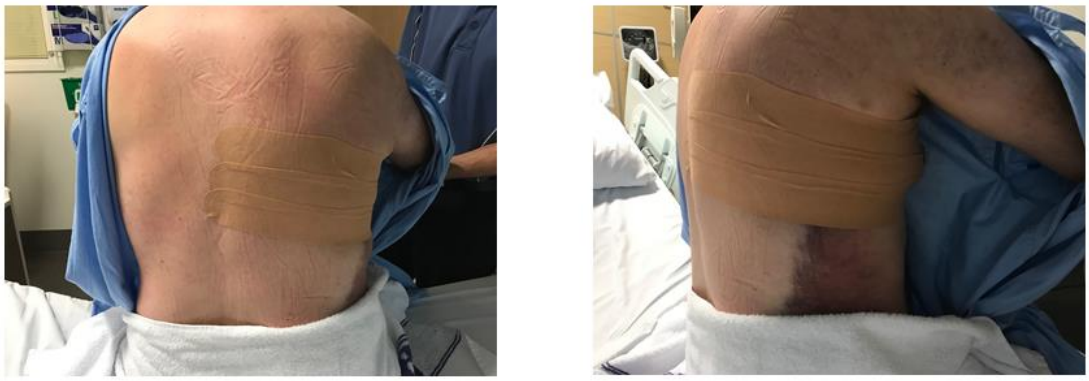

Figure 1. Kinesiotaping In Situ for One Participant (no. 5).

Table 1. Participants' Demographic and Clinical Data

Subject number	Sex	Age (years)	Mechanism of injury	Ribs fractured	Other injuries	Relevant past medical history	Hospital length of stay (days)
1	F	63	MVA	L anterolateral 4-9, R anterolateral 3-9	Sternal fracture	COPD, obesity, current smoker	9.2
2	M	19	MBA	L posterior 2-4	Splenic laceration, fractured L iliac wing	N/A	7.7
3	F	66	Fall from ladder	L anterior 5-8	Nil	COPD, OA, obesity, depression	5.5
4	M	58	Bicycle accident	R posterolateral 3-7	R scapula fracture	R shoulder surgery for dislocation	3.9
5	M	49	Bicycle accident	R lateral 2-8	R clavicle fracture	Lumbar 4/5 laminectomy	7.0

F = female, M = male, MVA = motor vehicle accident, L = left, R = right, MBA = motorbike accident, COPD = chronic obstructive pulmonary disease, OA = osteoarthritis.

Pain Scores

The pain scores at rest, during deep breathing and coughing, and while moving from supine to sitting for the 5 participants during the ABAB phases of the study are shown in Figures 2-4. As can be seen, there was considerable variability between participants in pain scores across the phases of the study. While no consistent pattern was evident, pain scores were, arguably, somewhat lower on the days when the kinesiotape was applied, evident in the mean (SD) values for the 5 participants shown in Table 2. In particular, when phases B1 (i.e., first application of kinesiotape, Day 2) and A2 (i.e., second baseline phase, Day 3) are compared, a decrease in pain would have been anticipated due to natural recovery over time, whereas the opposite was seen in that most pain levels were higher in A2 than B1 phases (Figures 2-4, Table 2). No clear pattern was evident for the least and greatest pain reported by participants (Table 2).

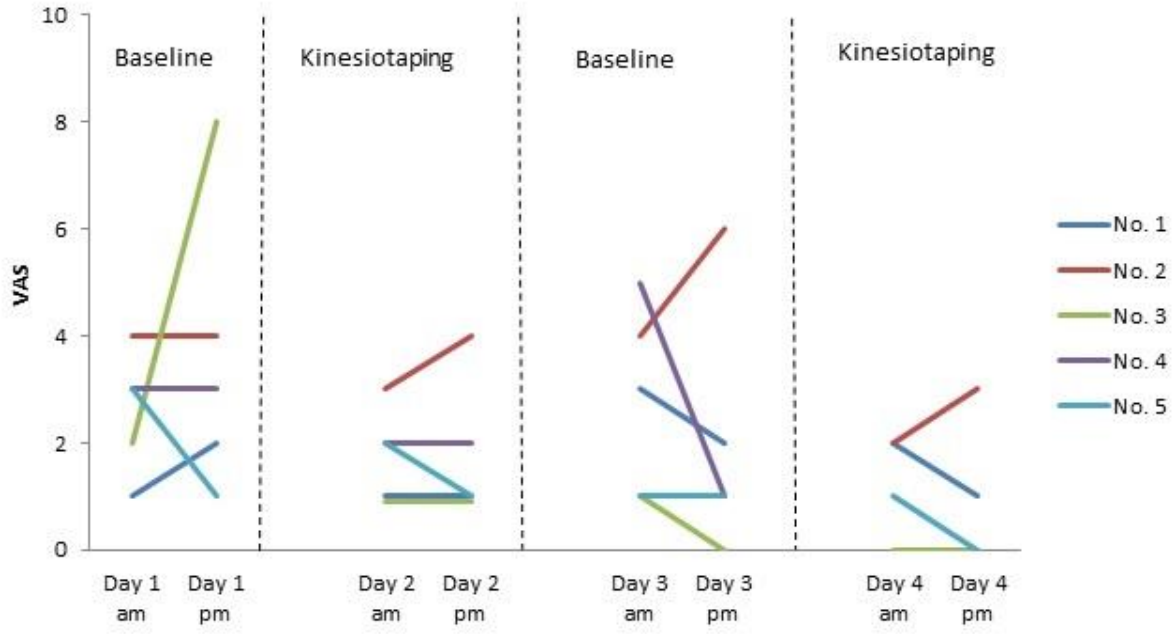

Figure 2. VAS Pain Levels at Rest for the 5 Participants Over the Phases of the Study.

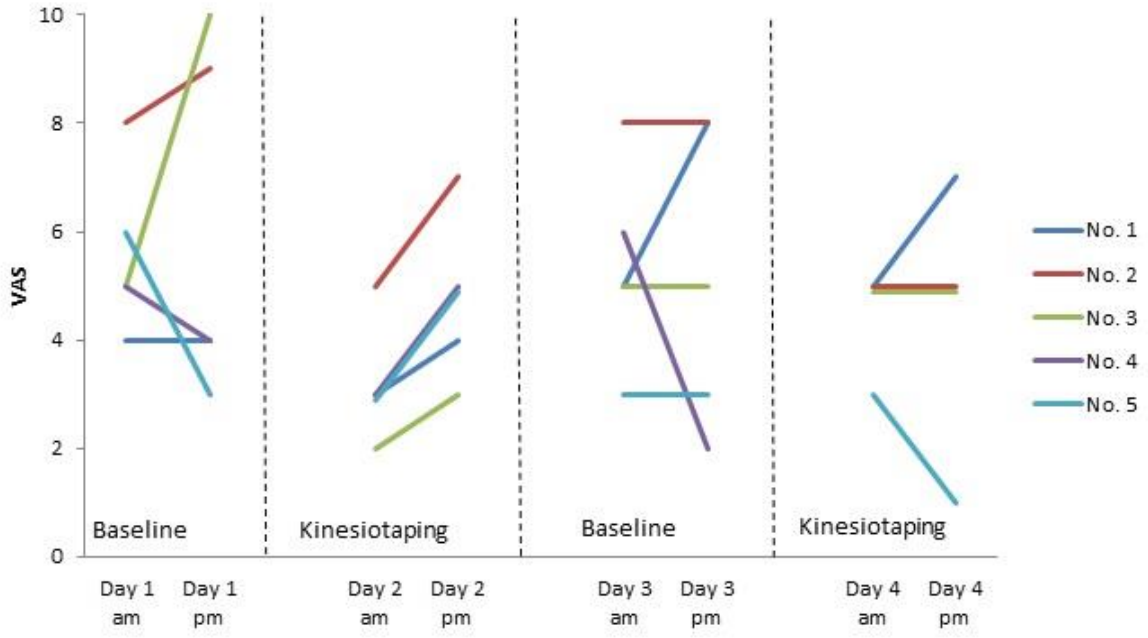

Figure 3. VAS Pain Levels During Deep Breathing and Coughing for the 5 Participants Over the Phases of the Study.

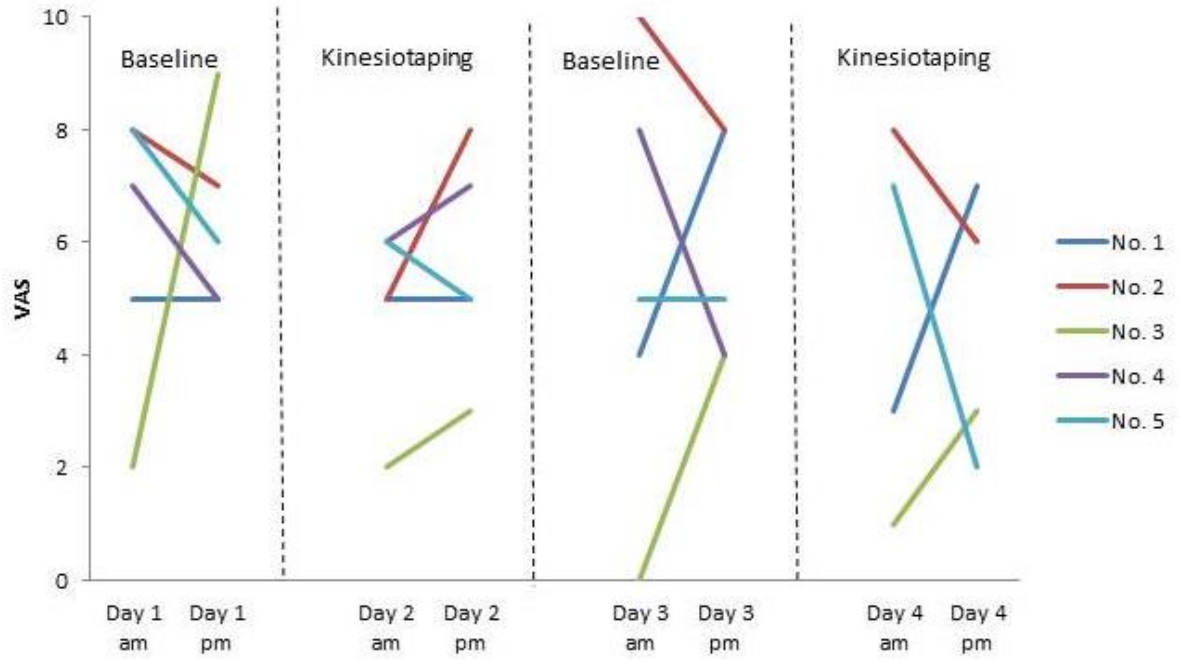

Figure 4. VAS Pain Levels While Moving From Supine to Sitting on the Edge of the Bed for the 5 participants Over the Phases of the Study.

Table 2. Mean (SD) VAS Pain Scores for the 5 Participants

Outcomes	Day 1, phase A1 (no kinesiotaping) n = 5	Day 2, phase B1 (kinesiotaping) n = 5	Day 3, phase A2 (no kinesiotaping) n = 5	Day 4, phase B2 (kinesiotaping) n = 4
Morning				
At rest	2.6 (1.1)	1.8 (0.8)	2.8 (0.8)	1.3 (1.0)
During deep B&C	5.6 (1.5)	3.2 (1.1)	5.4 (1.1)	4.5 (1.0)
Whilst moving	6.0 (2.5)	4.8 (1.6)	5.4 (1.6)	4.8 (3.3)
Afternoon				
At rest	3.6 (2.7)	1.8 (1.3)	2.0 (1.3)	1.0 (1.4)
During deep B&C	6.0 (3.2)	4.8 (1.5)	5.2 (1.5)	4.5 (2.5)
Whilst moving	6.4 (1.7)	5.6 (1.9)	5.8 (1.9)	4.5 (2.4)
Least pain in last 24 hours	1.6 (1.3)	1.4 (1.3)	1.2 (1.3)	0.8 (1.0)
Greatest pain in last 24 hours	7.6 (1.8)	7.6 (1.8)	8.1 (2.4)	4.8 (1.5)

Other Outcomes

Values for FVC (percentage predicted) were markedly variable between participants and across the study phases, with two participants (no. 1 and 2) showing an improvement in FVC over time, two participants (no. 4, 5) staying fairly static and the other (no. 3) showing a fall in FVC over the study period. No clear pattern was evident between the study phases. Maximum mobility levels showed a ceiling effect for three participants (no. 3, 4, 5) with the other two participants (no. 1 and 2) demonstrating an improvement in maximum mobility over time. There was no clear difference between study phases for maximum mobility levels.

Four of the five participants (no. 1, 2, 3, 4) self-reported zero skin irritation (VAS) from the kinesiotaping across the study period, with the fifth participant (no. 5) rating his skin irritation as 3 on day 4 and 0 on day 5. Skin irritation rated by the treating

physiotherapist was zero for 2 participants (no. 3, 4), 3 or less for 2 participants (no. 1, 2). The remaining participant (no. 5) was rated 7 on days 4 and 5, with redness, edema, and papules/vesicles apparent, necessitating removal of the tape. No specific intervention for skin irritation was required for any participant.

The usefulness of the kinesiotaping was rated as 5, 6, 9, 6 and 5 on the VAS for the 5 participants respectively. Three participants (no. 1, 3, 4) chose to leave the tape on after the intervention period. Comments from the participants were as follows: "The tape is no bother." (no. 1); "The days the tape was on [I] didn't feel any pain around the fracture site at times. More comfortable with tape on." (no. 2); "Really good, worthwhile, holds you all the time." (no. 3); "Felt it helped a little." (no. 4); "Felt more stable with tape on. Flexible, comfort." (no. 5).

Multimodal analgesia was used for pain control and showed considerable variability between participants. All received intravenous fentanyl (patient-controlled analgesia), oral tramadol, and oral paracetamol. Four participants also received oral oxycodone (no. 2, 3, 4, 5), 3 received an intravenous ketamine infusion (no. 1, 4, 5), and oral ibuprofen (no. 2, 4, 5). One participant (no. 1) was given a sternal block using a local anesthetic on day 1, and one participant (no. 3) received oral pregabalin. The types and dosages of analgesia decreased over the study duration for all participants.

Review of participants' medical records showed that four participants (no. 2-5) remained in a stable medical condition, with gradual clinical improvement and de-escalation of medical intervention over the study duration. One participant (no. 1), with bilateral rib fractures, and a significant past medical history of chronic obstructive lung disease, obesity, and smoking, developed pneumonia on day 4, necessitating intravenous antibiotics, from which she made an otherwise uneventful recovery.

DISCUSSION

The aim of this preliminary study was to investigate the effect of kinesiotaping for patients with rib fracture(s) on pain levels, pulmonary function, and mobility, with monitoring for skin irritation complications using a single-subject study design. Considerable variability was seen between participants and across study phases for pain scores. While no clear effect was evident there were lower pain scores and less variability on the days of kinesiotape application. Kinesiotaping did not appear to have a consistent effect on pulmonary function or maximum mobility. Marked skin irritation, necessitating the removal of the kinesiotape, occurred for one participant and the medical condition of one participant deteriorated due to the development of pneumonia, necessitating antibiotics. The marked heterogeneity of the patient sample, in terms of their rib injuries, concomitant injuries, co-morbidities, and analgesic regimen made comparisons between participants difficult.

The magnitudes of the reductions in rib fracture pain that we documented with kinesiotaping were similar to those reported by Czyzewski et al and Sareen et al, where VAS pain levels during deep breathing and coughing decreased in the order of 1.5 points immediately after the application of kinesiotaping.[8,9] The incidence of skin irritation that we documented, with 3 of 5 participants having skin irritation scores greater than zero (only 1 had major skin irritation), was higher than that reported previously for kinesiotaping. For example, Brockman and Klein and Imperatori et al observed no local skin reaction from kinesiotaping applied to 46 patients after pulmonary lobectomy and 23 patients after median sternotomy respectively.[12,13] It is possible that our ABAB study design, which necessitated the repeated application and removal of kinesiotaping across study phases, may have contributed to the skin irritation we documented. A single application of kinesiotaping may not have produced the same degree of skin irritation. Given our results, future studies investigating the effect of kinesiotaping for fractured ribs should document the frequency and severity of skin irritation. One participant in our study required antibiotics when she developed pneumonia. Her pre-existing medical conditions and severity of her rib fractures put her in a particularly high-risk category. Although unlikely, we cannot exclude the possibility that the kinesiotaping contributed to the development of pneumonia.

The clinical significance of our findings is unclear. Our anecdotal opinion, based on experience during this trial, is that kinesiotaping seemed most effective for those patients with unilateral rib fractures without extensive co-morbidities. Further research, preferably randomized controlled studies with larger sample sizes, is required to confirm and extend our results. However, the heterogeneous nature of this patient group, with respect to the nature of their rib fractures, concomitant injuries, past medical history, and analgesic management, will make it difficult to obtain comparable treatment groups in any future studies. It would also be of interest to undertake a study where different types of non-rigid strapping/taping are compared. While the reductions in pain levels that we documented were variable and relatively small, our impression was that pain was the outcome measure that best reflected any effect of kinesiotaping.

Limitations

Our study had several important limitations. Our sample demonstrated marked heterogeneity in terms of their injuries, co-morbidities, and analgesic management. Historically, this heterogeneity is typical of patients requiring hospital admission for rib fractures. It is clear that analgesic medication has a major role to play in the management of fractured ribs and we acknowledge the analgesics the participants received impacted the outcomes measured in this study. While it would have been preferable to have had a standardized analgesic regimen, this was beyond the scope of our introductory study. Another limitation is that the ABAB design of our study introduced the potential for an order effect, with spontaneous recovery over time being responsible for the improved outcomes seen during B phases (i.e., B1 and B2 phases on days 2 and 4) rather than the kinesiotaping. However, if our results are examined in more detail, lower pain levels were generally seen on day 2 (i.e., phase B1, kinesiotape on) compared to day 3 (i.e., phase A2, kinesiotape off), whereas the opposite result would be expected with spontaneous recovery alone. This finding suggests but does not prove that kinesiotaping seemed to reduce pain levels. Lastly, we did not attempt to investigate the mechanism by which kinesiotaping may have had its effect. Despite the introductory and exploratory nature of our study, we believe the results provide valuable information that can be used to inform future research.

CONCLUSION

This preliminary study found that kinesiotaping has the potential to reduce pain for patients with fractured ribs. However, given the exploratory nature of this study, further research is required, preferably randomized controlled trials with more homogenous samples and standardized analgesic regimens to clarify the effectiveness of kinesiotaping in the reduction of pain, improvement of pulmonary function and mobility following rib fractures.

DECLARATION OF INTEREST

The authors declare no conflict of interest.

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