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Scientific/Clinical Article

Repositioning the scapula with taping following distal radius fracture: Kinematic analysis using 3-dimensional motion system

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A B S T R A C T

Study Design: Cross-sectional and controlled laboratory study using pretest-posttest design.
Introduction: Patients with distal radius fracture (DRfx) report proximal segment problems. Taping is commonly recommended because it provides improved posture and function.
Purpose of the Study: This study aimed to investigate the 3-dimensional scapular kinematics and the effect of taping on the kinematics in participants with DRfx.
Methods: Twenty participants with a unilateral history of DRfx and 20 healthy controls participated. Scapular kinematics was assessed using an electromagnetic system. Three separate strips of elastic taping were applied for participants with DRfx over the arm, scapula, and middle and lower trapezius muscles through the paravertebral muscles. Afterward, the scapular kinematics was reassessed in taped condition.
Results: When participants with DRfx and healthy controls compared, the scapula was more downwardly rotated at 120° of humerothoracic elevation (mean difference [MD], 9.06°) and at 120° (MD, 9.04°), 90° (MD, 5.6°) of humerothoracic lowering, more upwardly rotated at 30° of humerothoracic lowering (MD, 5.1°). Taping showed a significant effect on kinematics; specifically, the scapula was more externally rotated (38.9° untaped vs 31.1° taped) and posteriorly tilted (−9.2° untaped vs −4.8° taped) during humerothoracic elevation and lowering for participants with DRfx.
Discussion: Participants with DRfx showed different scapular kinematics and taping resulted in changes on tested kinematic parameters during humeral movements. Differences in scapular motion during elevation with taping showed a specific pattern.
Conclusions: Overall, taping maintained a position likely to produce optimal rotator cuff function during early rehabilitation of patients with DRfx.
Level of Evidence: N/A.

Introduction

Distal radius fracture (DRfx) is among the most common upper extremity injuries reported by clinicians.[1] These injuries usually result in suboptimal outcomes because of pain and deformity.[2] Patients with DRfx report not only distal joint impairment but also proximal segment problems. Proximal segments are affected adversely by postural alterations and abnormal motions, which are done to compensate for distal segment impairments. Patients often adopt aberrant movements to avoid injured segment loading and compensate for the loss of motion and isolated muscle activity after DRfx.[3,4]

Scapular dysfunction is frequently reported following upper extremity injuries.[5] Altered alignment of the scapula may create mechanical dysfunction in proximal segments by inducing excessive force in the tissue, which then impairs proximal stability and influences force production in distal segments.[6] Our recent study[4] showed altered scapular behavior in patients with DRfx after injury and demonstrated increased scapular internal rotation and upward rotation, which may lead to secondary musculoskeletal problems.[4] Optimal scapular motion may be important for maintaining upper extremity motion because it transfers forces during physical activity.[7] Therefore, implementing appropriate therapeutic approaches to provide accurate energy transfer system including

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scapulothoracic joint as soon as possible following DRfx may provide additional benefits to upper extremity motor performance.

A number of treatment strategies, including active and passive techniques, are used to prevent scapular winging and optimize scapulohumeral rhythm through rehabilitation.[8] Recent studies have shown that passive methods, particularly taping, may increase neuromuscular control of the scapulothoracic joint immediately after injury.[9-11] Therefore, taping is often recommended during the rehabilitation period to improve proprioceptive feedback, posture, and function and to prevent injuries in various shoulder pathologies.[12] Several studies have investigated the acute effects of taping on various muscle activation properties[9,13,14] and joint kinematics.[10,11,14-16] Previous reports on some application techniques of taping reveal acute alterations in scapular position and orientation.[10,14,16] Researchers thus conclude that taping could afford mechanical correction, provide increased proprioceptive input, and optimize neuromuscular control in terms of muscular activation level, recruitment pattern, and onset of muscular contraction.[12,17] Therefore, taping could be an effective adjunctive approach with distal radius rehabilitation to optimize scapula behavior, which tends toward increased internal and upward rotation.

We proposed that taping could enhance upper extremity movement quality by repositioning the scapular in patients with DRfx. However, no study that investigates the effects of taping on proximal segment correction following distal problems has yet been published. This study aims to investigate the effects of scapular taping on 3-dimensional (3-D) scapular kinematics during dynamic humeral movement in patients with DRfx. The hypothesis of this study is that the taping application will effect the 3-D scapular orientation in participants with DRfx.

Methods

Participants

A total of 40 participants were recruited. Twenty participants with a unilateral history of DRfx treated by internal fixation and the same rehabilitation protocol with no signs of non/malunion of the fracture or pain or limitation during shoulder elevation participated in the study (Table 1). Patients were recruited at 6-8 weeks postoperatively. The inclusion criteria were no multiple joint injuries, no reflex sympathetic dystrophy, and no history of upper body surgery. Patients were excluded from the study when they reported tear at rotator cuff or long head of the biceps tendon, degenerative joint disorders, or other systemic or neurological disorders.

In addition, 20 age- and gender-matched asymptomatic participants without any history trauma or surgery related to upper body were recruited as healthy controls (Table 1). This study was a controlled laboratory study using within- and between-group comparisons.

Table 1
Characteristics and physical parameters of the cohorts

Characteristics	Participants with DRfx ($n = 20$) mean (SD)	Healthy controls ($n = 20$) mean (SD)	*P* value
Age (y)	44.6 (10.9)	43.2 (11.4)	.6
Height (cm)	169.2 (7.2)	172.7 (8.4)	.1
Weight (kg)	67.4 (10.3)	69.9 (12.5)	.4
Wrist pain severity on VAS (cm)	3.7 (2.4)	0 (0)	<.001
DASH score (points)	42.9 (24.6)	0 (0)	<.001

DASH = The Disabilities of the Arm, Shoulder and Hand; DRfx = distal radius fracture; SD = standard deviation; VAS = Visual Analogue Scale.
Data are given as mean and standard deviation. *P* value indicates the results of independent samples Student *t*-test.

The institutional review board approved the protocol for this study, and all participants were informed about the nature of the study and they had to sign a consent form.

Instrumentation

3-D kinematic data of the scapula and humerus were recorded using a Flock of Birds electromagnetic tracking device (Ascension Technology Corporation, Shelburne, VT) interfaced with Motion Monitor Software (Innovative Sports Training, Inc, Chicago, IL). Data collected by this electromagnetic tracking system are reliable, featuring calculated trial-to-trial, within-day, without removal of sensors intraclass correlation coefficient values ranging from 0.72 to 0.99 for our laboratory.[18] This method of measuring 3-D scapular kinematics has previously been validated by comparing data obtained from skin sensors to those obtained from acromion-fixed sensors.[19]

For data collection, sensors were attached to the skin; the thoracic sensor was located over the T1 spinous process, the scapular sensor was applied to the flattest aspect of the posterolateral aspect of the acromion,[20] and humeral sensors for each arm were applied over the posterolateral aspect of the humerus. Participants were asked to stand with their arms relaxed while specific bony landmarks were digitized. The standard protocol described by the International Society of Biomechanics was followed,[21] and the regression model suggested by Meskers et al[22] were applied to define the rotation center of the glenohumeral joint.

Experimental procedure

The participants were familiarized with the motion of scapular plane humeral elevation while maintaining "full-can" position. Each participant was asked to perform 3 full shoulder elevation motions in the scapular plane against gravity following a wooden pole set to 40° anterior from the frontal plane as a guide. Motions were controlled by a metronome, and elevation and lowering were performed for 3 seconds each. In addition, participants with DRfx were asked to perform another 3 full shoulder elevation 30 minutes after taping applied. All tests were performed in the same session; therefore, the sensors remained attached to the participants throughout testing with and without taping.

The taping was applied to participants with DRfx by the 10-year–experienced physiotherapist. Three separate I-shaped strips of elastic tape (Kinesio Tex Gold; Kinesio USA LLC, Albuquerque, NM) 5 cm wide were used for postural correction (Fig. 1). The first strip, aiming to enhance elbow supination, was spirally applied over the arm starting from the volar side of the distal radius and crossing the elbow anteriorly up to the mid-humeral level. The second strip, aiming to control scapular position, was applied over the scapula starting from the coracoid process and crossing the glenohumeral joint from the anterior aspect up to the medial border of the scapula. The last strip, aiming to facilitate erect posture and proprioceptive feedback, was applied over the middle and lower trapezius muscles through the paravertebral muscles. Tape size was measured from the starting point to the end while participants stood in anatomic position.

Data analysis

The kinematic recordings obtained from the affected side of the participants with DRfx under both untapped and taped conditions and from the side-matched shoulders of the controls were further analyzed. To define scapular rotations, the y-x′-z″ sequence was used; here, the first rotation was defined as scapular internal-external rotation, the second was defined as scapular upward-downward rotation, and the third was defined as the scapular