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A Newly Designed Tennis Elbow Orthosis With a Traditional Tennis Elbow Strap in Patients With Lateral Epicondylitis

Hossein Saremi,[1] Vahid Chamani,[2,*] and Reza Vahab-Kashani[3]

[1]Hamedan University of Medical Sciences, Hamedan, IR Iran
[2]Parsatavanbakhsh Orthotics and Prosthetics Clinic, Hamedan, IR Iran
[3]University of Social Welfare and Rehabilitation Sciences, Tehran, IR Iran

[*]*Corresponding author*: Vahid Chamani, Parsatavanbakhsh Orthotics and Prosthetics Clinic, Hamedan, IR Iran. Tel: +98-8132515680; +98-9183180195, E-mail: chamani.op@gmail.com

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Abstract

Background: Lateral epicondylitis is a common cause of pain and upper limb dysfunction. The use of counterforce straps for treatment of lateral epicondylitis is widespread. This kind of orthosis can be modified to have a greater effect on relieving pain by reducing tension on the origin of the extensor pronator muscles.
Objectives: To determine the immediate effects of a newly designed orthosis on pain and grip strength in patients with lateral epicondylitis.
Materials and Methods: Twelve participants (six men and six women) were recruited (mean age = 41 $\pm$ 6.7 years) and evaluated for pain and grip strength in three sessions. A 48-hour break was taken between each session. The first session was without any orthosis, the second session was with the new modified tennis elbow orthosis, and the third session was with a conventional tennis elbow strap.
Results: Both counterforce straps were effective. However, significantly more improvement was observed in pain and grip strength after using the newly modified orthosis ($P < 0.05$).
Conclusions: The newly designed strap reduces pain more effectively and improves grip strength by causing greater localized pressure on two regions with different force applications (two component vectors versus one).

Keywords: Tennis Elbow, Lateral Epicondylitis, Orthosis, Pain, Grip Strength

1. Background

Lateral epicondylitis, also known as "tennis elbow", is a common disorder of the upper extremities caused by overuse of the wrist extensor muscles (1, 2). Tennis elbow seems to result most commonly from overuse of the extensor carpi radialis brevis (ECRB) muscle. Repetitive microtrauma of this muscle results in a primary tendinosis with or without involvement of the extensor digitorum communis (3). It occurs in approximately 3% - 9% of ordinary people and 50% of tennis players (1, 4). Lateral epicondylitis is also a work-related syndrome, causing lateral epicondyle pain during work or activities. Symptoms are worsened during resistance against supination or dorsiflexion of the wrist, especially when the elbow joint is in full extension, and is aggravated during grasping activities (5). A medical history and physical examination are frequently used to diagnose this disorder (6, 7). The onset of tennis elbow is pain that starts gradually and radiates from the distal end of the lateral epicondyle toward the distal forearm (8).

The main complaint of patients with this condition is pain in the elbow and reduction in grip force (9). Many studies support the positive effects of counterforce braces on reducing pain and increasing grip strength in these patients (10-16). Nirschl (11) and Wadsworth et al. (12) supported the theory that pressure from the brace on the extensor muscles can lessen muscle-tendon tension in the lateral epicondylar region (13). Counterforce braces have immediate positive effects on the symptoms of tennis elbow, placing pressure on the origins of muscle tendons, especially the ECRB and extensor digitorum communis (12-15). Hence, we decided to design and fabricate a new orthosis that more effectively reduces the tension of the extensor tendon origin compared to the traditional tennis elbow strap.

2. Objectives

This study investigated the immediate effects of our new modified orthosis on pain and grip strength compared to a traditional tennis elbow strap in patients with lateral epicondylitis.

3. Materials and Methods

In this non-randomized double-blind clinical trial, 12 participants with lateral epicondylitis (six men and six women), aged 31 to 55 years (mean 46.33 years) were chosen to participate. All participants had symptoms of lateral epicondylitis for at least six weeks, and had at least three positive results out of four diagnostic tests for tennis elbow (15). They had not used any other treatments for tennis elbow, including steroid injections. The exclusion criteria were: other anomalies or disorders of the hand, forearm, shoulder and neck regions; previous surgery on the affected extremity; history of corticosteroid injections or other invasive tennis elbow treatment protocols within six months before entering the study; and not using an orthosis regularly. The study was approved by the ethics review committee of the University of Social Welfare and Rehabilitation Sciences. All participants signed informed consent before entering the study.

3.1. The New Modified Elbow Orthosis

The newly designed tennis elbow orthosis (Figure 1A - D) has the same structure as the traditional counterforce strap (Figure 1E), which is made of neoprene with a thickness of 3 mm, a width of 8 cm, and 5% of every patient's elbow circumference. The only difference is that there are two separated medium-density fiberboard wedges incorporated into the proximal part of the new orthosis, to be placed on the ECRB and extensor digitorum communis muscles. This was done to divide the counterforce into vertical and horizontal forces (Figure 2) toward the origins of these muscles instead of the single vertical counterforce of the traditional tennis elbow strap (TEKNO TAN Company, Iran). The new orthosis is positioned 2.5 cm below the lateral epicondyle. We have named this new device a "wedged brace".

3.2. Outcome Measures

Grip strength and pain were the outcome measures in this study. Grip strength was evaluated at each session with a dynamometer (Jamar Hydraulic Hand Dynamometer, PC 5030 J1) in the standardized upper limb position, as recommended in previous studies (wrist in neutral position, forearm in pronation, elbow in 90° of flexion, and shoulder in slight abduction). Mean values were calculated to provide one score for each testing session.

To familiarize the participants with the testing procedure, they initially practiced by holding the dynamometer with the uninvolved upper extremity. A visual analogue scale was used to measure pain. After assessing the participants regarding the inclusion/exclusion criteria, they were referred to an orthotic and prosthetic clinic for a baseline evaluation at first session, while wearing no brace. At that time, they received the newly designed orthosis. After 48 hours of regular use of the new orthosis, outcome measures were evaluated again at the second session. They then received the traditional tennis elbow strap at least 48 hours after removing the new orthosis, in order to minimize the carryover effect. After 48 hours of regular use of the traditional tennis elbow strap, the outcome measures were again evaluated at the third session.

3.3. Data Analysis

Repeated measurement of analysis of variance (ANOVA) was used to statistically test for significant differences. The least-significant difference test was used as post-hoc calculation, to show pairwise differences among testing conditions. The statistical analyses were carried out using SPSS version 22. A P value of < 0.05 was considered significant.

4. Results

Twelve participants with a mean age of 46.33 ± 6.7 years and who were diagnosed with tennis elbow were enrolled in this study. The outcome measures were analyzed by grip strength and pain in three sessions. Increased grip strength was observed at the second and third sessions (Table 1).

Mauchly's test confirmed the sphericity of co-variances and indicated no significant differences in covariance (P = 0.184). The post-hoc pairwise comparison between levels of grip force at the three sessions showed that grip force was significantly different between the first and second sessions and also between the first and third sessions (Table 2). Thus, the newly designed orthosis was more effective at increasing grip force in tennis elbow patients.

A reduction was seen in the visual analogue scale pain scores (Table 1). A pairwise comparison between sessions (Table 2) indicated significant differences between the first and second sessions (P = 0.001). The mean difference between the first and third sessions was not significant in the pairwise comparison test. Thus, the newly designed orthosis had a better effect on pain reduction compared to the traditional tennis elbow strap (Figures 1 - 3).

5. Discussion

There are several primary techniques of conservative intervention for relieving the pain of tennis elbow. According to Irani's theory, counterforce orthoses have an

Table 1. Mean and Standard Deviation of Outcome Measures in Lateral Epicondylitis Patients Over Three Sessions

	First Session[a]	Second Session[b]	Third Session[c]
Visual analogue scale pain score (measured in centimeters on a sliding scale)	7.16 ± 2.40	3.58 ± 2.10	5.50 ± 2.71
Grip strength, kgF	6.17 ± 3.35	8.96 ± 3.80	8.17 ± 2.73

[a] Baseline with no brace.
[b] While using new design orthosis.
[c] While using traditional tennis elbow strap.

Table 2. Statistical Significance (P Value) in Outcome Measures Between First Session and Second Session, First Session and Third Session, and Second Session and Third Session

	Between First and Second Sessions	Between First and Third Sessions	Between Second and Third Sessions
Visual analogue scale pain score	0.001	0.112	0.072
Grip strength, kgF	0.038	0.033	0.353

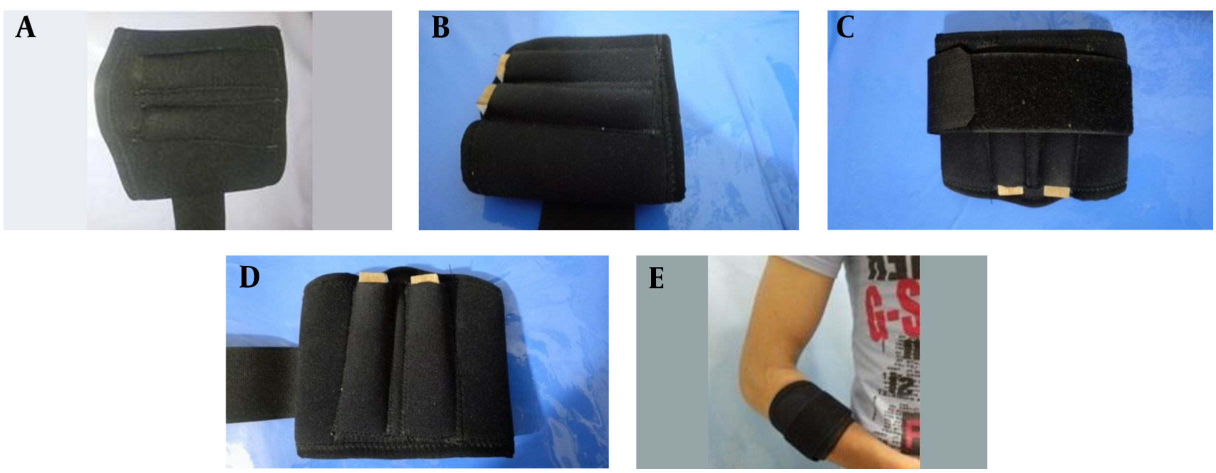

Figure 1. A - D, Newly Designed Tennis Elbow Orthosis; E, Traditional Counterforce Strap

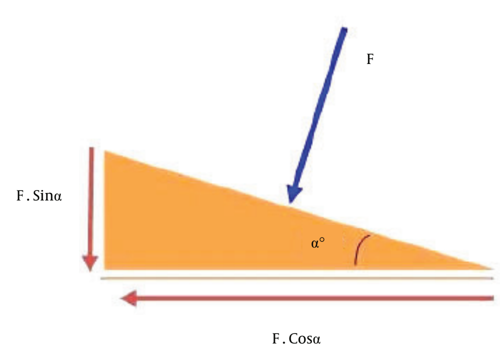

Figure 2. Horizontal and Vertical Vectors of Counter Forces Applied in Newly Designed Brace

immediate effect on pain by broadening the area of applied stress on the ECRB muscle (16), and the application of orthoses can immediately relieve pain. These are also more acceptable during daily activities compared to other modalities, such as steroids, ultrasound, laser, massage, and exercise therapy (17, 18). Different kinds of orthoses have been used for reducing pain and improving grip strength. Biomechanical studies have shown that a forearm orthosis can decrease the forces acting on the ECRB origin if the pressure pad is placed over the belly of the ECRB. However, it tends to be more effective if the pressure pad is positioned distal to the lateral epicondyle (19, 20).

In their study, Jafarian and colleagues used a double-layered pressure pad in the elbow strap, and found that the sleeve, which applied generalized compression around the elbow area rather than specifically to the area distal to the lateral epicondyle, increased pain-free grip strength, suggesting that specific compression may not be neces-

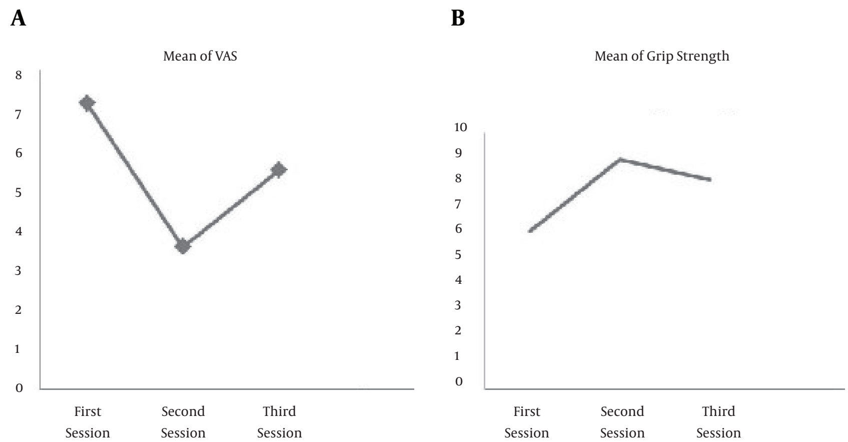

Figure 3. A, Mean of Visual Analogue scale Scores; B, Mean of Grip Strength

sary (14). Sadeghi-Demneh and Jafarian compared the immediate results of an elbow counterforce band, an elbow counterforce sleeve, and a wrist splint with a placebo, and found that the elbow counterforce orthosis was more effective than the wrist splints (15). These authors reported that applying a counterforce orthosis at the elbow (either a strap or sleeve) improved pain-free grip strength in individuals with lateral epicondylitis when tested immediately after application. In contrast, a wrist splint did not change pain-free grip strength. There were no differences between the use of the elbow strap or the elbow sleeve in improving pain-free grip strength. These results are in agreement with those reported by Struijs and colleagues (17), who found that orthotic treatment can be useful as an initial therapy for lateral epicondylosis.

Bisset and colleagues compared the effects of two types of braces, and found no difference between forearm and forearm-elbow braces. The latter was a standard counterforce brace with an additional strap that wrapped above the elbow for reducing pain and improving grip strength. Both were similarly effective (10).

Hence, we decided to design a new elbow counterforce brace that could apply pressure not only vertical to the extensor tendon origin, but also in the horizontal direction, in order to more effectively reduce tension. Our newly designed orthosis is actually a modification of a traditional counterforce brace, and includes double separated medium-density fiberboard wedges incorporated into the proximal part, to be placed on the bulk of the ECRB and extensor digitorum communis muscles. We call this newly designed orthosis a "wedged brace". We believe that the vector of the applied forces could be more horizontal and thus more effectively provide greater relaxation to the ECRB and extensor digitorum communis tendon origins.

This study investigated the immediate effect of our new brace on pain and grip strength compared to traditional tennis elbow straps in patients with lateral epicondylitis. The findings demonstrated that both of the studied counterforce braces reduced pain and increased grip force in individuals with lateral epicondylitis, when assessed immediately after application. This finding is similar to other studies (10, 12, 14, 15). However, our newly designed brace was significantly better at reducing pain and improving grip strength (Table 2).

There were some limitations to this study. Since it was a pilot study of the new wedged brace, the number of participants was not high enough to allow for stronger conclusions. Also, this study investigated only the immediate effect of the wedged brace; its long-term effects still need to be investigated.

5.1. Conclusions

The traditional counterforce brace and the new wedged brace had positive effects on pain and grip strength in patients with lateral epicondylitis in this study. However, the wedged brace was significantly more effective at improving pain and grip strength due to more localized pressure on two regions, the ECRB and extensor digitorum communis muscles, with different force applications (two component vectors versus one) on the extensor origin. This can create a more effective counterforce.

Further studies with larger numbers of patients are necessary to prove this superior effect. The participants must not have received other treatments for lateral epicondylitis. It is hoped that the present study can lead to the design of other braces with more transverse force on the extensor pronator origin, in order to more effectively reduce pain and improve grip strength.

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