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Personalized, 3-Dimensional, Computerized Mobilization of the Cervical Spine for the Treatment of Chronic Neck Pain - A Pilot Study

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Abstract

Background: Previous studies have shown that computerized mobilization of the cervical spine (CMCS) is safe and potentially effective treatment for chronic neck pain (CNP).

Objective: The investigation of safety, clinical outcome, and changes of specific physiological parameters, in CNP patients, treated with individualized, 3-dimensional CMCS.

Participants: Nine patients with CNP.

Interventions: A cradle capable of CMCS was utilized. Each participant underwent individualized treatment sessions, lasting 20 min each, carried out biweekly over 6 weeks.

Main Outcome Measurements: Pain visual analog scale (VAS), Neck disability index (NDI), pressure pain thresholds (PPT), cervical range of motion (CROM), joint position error (JPE), forward neck tilt (FNT), and flexion relaxation ratio (FRR).

Results: Minor side effects encountered during the study. Comparing baseline measurements with measurements after treatment completion: VAS scores dropped by 2.3 points (p=0.04). NDI improved, but this improvement was not significant (p=0.086). CROM increased, on the average, by 11% but this increase was insignificant (p=0.061). JPE decreased from 2.88° to 1.14° (p<0.01). PPT increased from 1.27 kg/cm^2 to 2.44 kg/cm^2 (p=0.043). FNT insignificantly decreased from 20.36 cm to 19.02 cm (p=0.104). Left-sided FRR significantly increased (p=0.017).

Conclusions: This study provides preliminary evidence that suggest that personalized, 3-dimensional, CMCS is a safe treatment. This novel treatment may positively change cervical neuromuscular control, and the processing of proprioceptive and nociceptive information.

Keywords: Chronic neck pain; Magnetic resonance imaging; Computerized tomography; Cervical spine

Abbreviations: CROM: Cervical Range of Motion; CMCS: Computerized Mobilization of the Cervical Spine; CT: Computerized Tomography; EMG: Electromyography; FNT: Forward Neck Tilt; FRR: Flexion Relaxation Ratio; JPE: Joint Position Error; MRI: Magnetic Resonance Imaging; NDI: Neck Disability Index; CNP: Chronic Neck Pain; PPT: Pressure Pain Threshold; TTH: Tension-Type Headache; VAS: Visual Analogue Scale (pain)

Introduction

Chronic neck pain (CNP) is the most prevalent pain syndrome after low back pain [1]. The pathogenesis of CNP is not yet fully understood [1,2]. Manual therapy is potentially a promising avenue for the management of CNP; yet, as several meta-analyses indicate, the efficacy of manual approaches has yet to be conclusively supported [2-4]. In a previous pilot trial, we showed that computerized mobilization of the cervical spine confined to the sagittal plane is a safe and potentially effective treatment of CNP. Specifically, the treatment yielded improvements in objective physiological measures, as well as in patients' self-reports of their condition, as reflected in reliable questionnaires [5,6]. In a second pilot trial we showed that a 6-week treatment course of biweekly computerized mobilization with a sequence of movements in the sagittal, coronal and horizontal planes is followed by significant reduction of CNP, improvement in neck range of motion, and reduction in joint position error [7].

Whereas our first two trials employed limited neck mobilization in one or several consecutive planes, the purpose of the current trial is to apply natural, combined, mid-range movements (combined rotation and translation in the sagittal, coronal and horizontal planes). The intervention is personalized for the patient through a two-stage process: 1) the "teach" phase, which entails recording the course of movement of the patient's head and neck as the neck is mobilized by the physical therapist; and 2) the treatment phase, in which the

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recording in the first phase is used as a template for a precise, continuous, computerized neck mobilization that maintains six degrees of freedom.

Several physiological parameters deviate from the normal range in patients with CNP. These parameters include reduced neck muscle endurance (as compared with that of healthy patients), over-contraction [illegible] multiple active [illegible] flexor muscles, reduced cervical range of motion (CROM), abnormal forward [illegible] [6-9]. [illegible] state of central sensitization as reflected in low mechanical pain thresholds [9,10]. The aim of the current trial is to gather preliminary data, with respect to the effects of individualized, 3-dimensional, computerized neck mobilization, on several physiological parameters, that deviate from the normal range in CNP patients. It is also the goal of this trial to obtain preliminary safety data following this novel treatment.

Materials and Methods

We conducted an open pilot trial, in which patients with CNP were treated for 6 weeks at the physical therapy department of the Hillel Yaffe Medical Center, Hadera, Israel (Institutional review board approval: [illegible]). Ethical approval was also granted by the Israeli Ministry of Health Medical Research Ethics Committee. The trial was registered in the NIH ClinicalTrials.gov database (ClinicalTrials.gov [illegible]).

Participants

We screened [illegible] patients with CNP, who had been referred to the Hillel Yaffe medical center, by their primary physicians, and recruited ten patients (seven women, three men), with a mean age of 47 (± 11.1) years. One patient was lost to follow up subsequent to his initial screening. All recruited nine patients completed the trial. Participants were eligible for inclusion if they were 18-65 years of age and had been suffering for at least [illegible] CNP that [illegible] attributed to whiplash injury, facet joint disorder, muscle sprain, or from CNP associated with myofascial trigger points, according [illegible] IASP classification of chronic pain [11].

Patients were excluded if they showed evidence of cervical myelopathy or radiculopathy, evaluated through physical examination, cervical [illegible] CT/MRI (computerized tomography/magnetic resonance [illegible]), and electromyography (EMG) of the upper extremity muscles. We also excluded patients with cerebrovascular disease, significant osteoporosis, or underlying malignant disease. In addition to the patients with CNP we recruited ten healthy volunteers as a control group for the measurements of flexion relaxation ratio. Participants provided informed written consent.

Computerized mobilization

Computerized mobilization treatment was performed with the Occiflex device (Figure 1) [6,7]. This device was developed to optimize neck mobilization. It consists of an adjustable therapeutic bed and a cradle, capable of any movement in three-dimensional space with six degrees of freedom (Figure 1). The device can record any head-and-neck mobilization that the therapist performs on the patient. After a "teach" phase, in which the device records a series of individualized mobilizations for the patient, the device performs treatment automatically, for 20 min, by carrying out multiple precise repetitions of the recorded mobilization, utilizing slower angular speed of up to 2°/s (treatment phase). During the treatment phase the patient's head is not restrained, and he or she can sit up at any time. The patient holds a safety brake that when activated leads to immediate cessation of treatment.

Figure 1: The Occiflex device. A computer-controlled, non-invasive robotic system moves the cradle in dynamic, gentle, three-dimensional oscillations. Left: Teach phase. Note that the cradle is moved aside to allow manual mobilization. Right: Treatment phase. The recorded mobilization in the teach phase is used as a template for repeated oscillatory mobilizations.

The mobilization used in this trial was a slow oscillatory osteokinematic, mid-range mobilization, avoiding the end of the available neck range of movement. The determination of the specific chosen course of movement was based on three principles: A) Stretching muscles that had active trigger points. B) Mobilization of facet joints if prior information indicated their involvement in the etiology of CNP. C) Extending limited neck range of movement following the baseline CROM examination. During the "teach" and treatment phases the patient lay supine in a quiet room. The upper part of the body from below the lower margin of the scapula was raised by 15°, yet the occiput was at the same level as the C7 posterior spinal process, so the initial neck angle at the sagittal plane was 0°. The knees were bent and supported by a cylindrical cushion to provide a comfortable body posture. The maximal range of movement allowed in the trial was 0°-80° in the sagittal plane, 0°-70° in the horizontal plane, and 0°-60° in the coronal plane. The angular velocity allowed was [illegible]-2°/s. Changes in the course and range of movement were based on the patient's response to treatment and the physical therapist's clinical judgment. Each patient underwent the therapeutic procedure once biweekly for 6 weeks.

Outcome measurements

We collected the following primary outcome measurements, by a blind observer, before, during and after the treatment course: pressure pain thresholds (PPT), cervical range of motion (CROM), joint position error (JPE), flexion relaxation ratio (FRR), and forward neck tilt (FNT). In addition, we recorded the neck disability index (NDI), pain visual analog score (VAS), and safety, as reflected in the occurrence of adverse effects. In what follows, measurements obtained at week 1 of treatment are referred to as "baseline" measurements; these measurements were taken before commencement of the treatment procedure. Other measurements taken during the course of treatment were collected immediately before the computerized mobilization procedure. Each patient underwent two follow-up examinations, carried out 2 and 6 weeks, respectively, after completion of the 6 weeks of treatment. The outcome measurements were collected