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Case report

A case report on the use of vibration to improve soft tissue extensibility after major trauma

Mark Paul Brewin BSc (Hons), MSc, MIPEM, PhD [a,*], Carole J. Bexon Dip COT [b], Sarah C. Tucker MBChB, FRCS (Plas), MSc (Clinical Education) [c]

[a] Salisbury Burns Unit, Salisbury NHS Foundation Trust, Salisbury, Wiltshire, United Kingdom
[b] Wessex Rehabilitation Centre, Salisbury NHS Foundation Trust, Salisbury, Wiltshire, United Kingdom
[c] Plastic Surgery, Oxford University Hospitals NHS Trust, John Radcliffe Hospital, Oxford, United Kingdom

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ABSTRACT

This report presents a case where vibration training to the arm alone, as opposed to whole-body vibration, was used to aid rehabilitation to a serious traumatic injury. An improvement in soft tissue extensibility to a major traumatic wound to the wrist and forearm has been noted in a therapy plan including vibration under stretch. After 12 weeks of intensive therapy, a considerable improvement was seen in both the active extension of the wrist and the composite extension of all fingers. This may highlight the use of vibration, as an adjunct to therapy, to specific areas of the human body for improving outcome from traumatic injury.
Level of Evidence: IV.

Introduction

Studies have shown that low-magnitude, high-frequency (LMHF) whole-body vibration (WBV) can act as an anabolic stimulus to both bone and muscle in animal studies.[1,2] However, increases in muscle strength or reduction in stiffness have not been shown in human studies.[3,4] A more recent study has looked at the effect of low magnitude, 0.3 G peak-to-peak, high-frequency WBV on the structural and material properties of the flexor carpi ulnaris tendon of the rat.[5] They conclude that vibration may serve as an anabolic stimulus to tendon similar to its effects on bone and muscle.

Over the course of daily functional challenges, the human musculoskeletal system is subjected to exceptionally few high-strain (2000-3000 microstrain), low-frequency (1-3 Hz) events but is bombarded by persistent low-strain (<5 microstrain), high-frequency (10-50 Hz) mechanical vibrations.[6] It is known that an introduction of mechanical force to sites of injury aids in tissue remodeling, but functional movement restrictions after injury often prevent optimal loading to induce tissue healing.

Low-magnitude, high-frequency vibration (LMHFV) is a form of WBV that operates at hypogravity accelerations. It has been proposed that LMHFV can act as a surrogate mechanical stimulus.[7] Indeed, the same article concluded that vibration therapy may be a useful tool to accelerate healing of other tissues, such as bone, in multitrauma injuries without inhibiting ligament healing.

Purpose of the study

This study describes the effect of LMHFV vibration training on the recovery from a serious traumatic injury. The purpose of this report was to highlight that the vibrational aspect of the treatment plan for therapy improved the range of movement and soft tissue extensibility in the wrist and forearm to regain composite finger and wrist extension. Improved soft tissue extensibility in the flexor apparatus may also facilitate improved active finger flexion.

Methods

A 30-year-old male was admitted to hospital with multiple lacerations to the left forearm. This injury caused major trauma to

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* Corresponding author. Salisbury Burns Unit, Salisbury NHS Foundation Trust, Odstock Road, Salisbury, Wiltshire, SP2 8BJ, United Kingdom.
E-mail address: mark.brewin@salisbury.nhs.uk (M.P. Brewin).

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both the wrist and forearm with 100% division of radial and ulnar arteries, median and ulnar nerves, and all flexor tendons, both at the level of the wrist and in the distal forearm. Some tendons sustained segmental damage. In International Classification of Diseases terminology, this patient presented with multiple injuries of forearm (S59.7), and this included injuries classifiable to more than one of the categories S50-S58.

The initial surgery was carried out at John Radcliffe Hospital (Oxford, UK) to provide revascularization of left forearm and hand. At 8 days, further surgery was performed. All flexor digitorum profundus and flexor digitorum superficialis muscles were repaired with buddying of both the little and ring finger. The flexor carpi ulnaris was also repaired but not the flexor carpi radialis due to its poor quality. The median and ulnar nerves were also repaired. The area of skin defect was approximately 10 cm $\times$ 10 cm predominantly over the muscle bellies. This area was covered with split skin graft (SSG) taken from the thigh.

At 3 months, the patient was admitted to the Wessex Rehabilitation Centre (WRC, Salisbury NHS Foundation Trust, UK). The patient attended the center for therapy 4 days a week over a 12-week period. The therapy focused on restoring soft tissue extensibility and tendon glide under the SSG and throughout the forearm, where there was considerable tethering. The range of hand therapy tasks to improve soft tissue extensibility included the routine use of elastic therapeutic tape for scar softening, massage, regular passive stretches, and orthoses.

The patient attended for a full-time rehabilitation program. This involved both physiotherapy and occupational therapy (OT) for five and a half hours a day. The patient attended the facility for between 2 and 4 days a week, depending on his personal commitments. The patient had physiotherapy intervention for 2 hours a day. This intervention involved activities to regain pinch and grip function, for example, picking up nuts, lifting poles, use of therapeutic putty, functional activities such as bat and ball games. Once a day, the patient had wax treatment to warm up the forearm and hand tissues, followed by passive stretches. The patient had isolated stretches of each joint to maintain full passive flexion and extension of all joints in the wrist and hand. He also had stretches for composite wrist and hand extension and flexion to improve soft tissue extensibility.

Hand therapy intervention included the use of Kinesiotape (Kinesio, Japan) across the forearm scar and orthotic intervention. The patient used a static “letterbox” orthosis for wrist and finger extension mobilization, as shown in Figure 1. This was fabricated with 5 layers of thermoplastic sheet (X-LITE Premium; Allard International, Helsingborg, Sweden) and is classified as an index finger, small finger and wrist extension mobilization orthotic device. The purpose of this device was to maintain a stretch on the scar tissue on the volar aspect of the forearm, with the aim of remodeling and lengthening this scar. The patient wore the device for periods of around half an hour a day, for a maximum total end range time of 4 hours per day. It was recommended that it was used during the day, so the patient could monitor his skin condition, especially in relation to his loss of sensation. However, the patient reported that he also used the device at night. There were no problems with skin damage or vascular compromise. Other hand therapy interventions included mirror therapy for sensory relearning.

OT intervention, for the remaining three and a half hours a day, involved the use of activities in the light workshop, industrial workshop, and daily living bungalow. In the early stages of treatment, light workshop in OT activities involved the use of remedial games to restore pinch and grip function and light functional activities such as origami. However, the patient spent most of his OT time in the industrial workshop working on a wide range of carpentry projects, graded from light to heavier tasks. These involved a range of activities including hammering, hand sawing, screw driver work, use of electric drills, and use of woodwork machinery, such as pillar drills. All activities involved working on grip strength, restoration of hand function, and learning how to use a hand with significant loss of sensation.

The therapists have used vibration on scar tissue at WRC. This use of vibration was noted as an incidental finding in the treatment of patients with tethered flexor tendon injuries. Vibration was applied with the flexor tissues on maximum stretch. This is achieved with maximum finger and wrist extension. The clinical reasoning behind the use of vibration as therapy intervention is the aim of targeting and changing scar tissue, rather than muscle. The vibration is imparted either by the manual use of a compressed air sander in a carpentry workshop or by placement of the hand under bearable pressure on a vibroplate for up to an hour per day, as shown in Figure 2. Initially, the activity of air sanding within the carpentry department had been used as a general OT task for hand grip. The activity was frequently used for an hour a day, once the patient had reached the stage of six week after repair of flexor tendons. However, both the therapists and the patients noticed that there seemed to be a benefit from the vibration itself. Patients commented that their wrist extension movement improved following the use of the air sander and that their forearm scar felt softer. Based on these observations, the air sander was then used with the scar tissue on maximum stretch for treatment of the scar and tendon tethering through the forearm for the following patient.

The compressed air sander (Georges Renault, St. Herblain, France) works with low-amplitude, high-frequency motion. The latter specifications have not been measured and are not

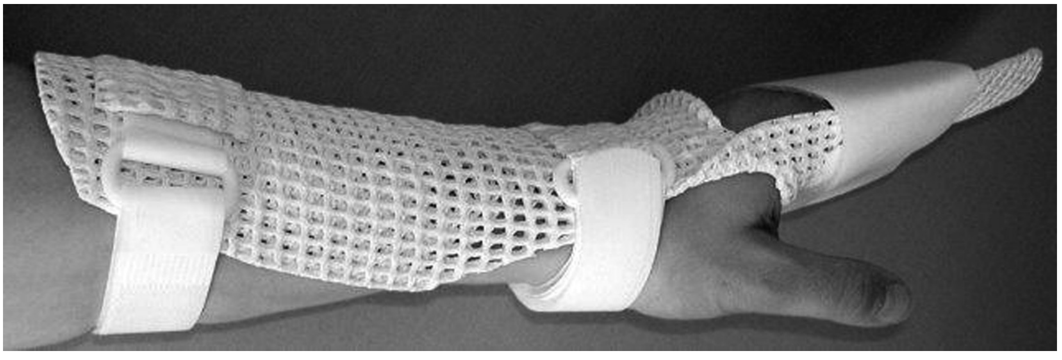

Fig. 1. This shows an example of a “letterbox” orthotic device.