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Superimposed electrical stimulation improves mobility of pre-stiff thumbs after ulnar collateral ligament injury of the metacarpophalangeal joint: A randomized study

L'électrostimulation surimposée améliore la mobilité du pouce pré-raide après blessure du ligament collatéral ulnaire de l'articulation métacarpo-phalangienne : une étude randomisée

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Abstract

Objective. – This study aimed at testing the ability of the superimposed electrical stimulation technique to restore the mobility of pre-stiff thumbs after operative repair for rupture of the ulnar collateral ligament.

Material and methods. – Eight patients demonstrating a pre-stiff metacarpophalangeal joint were involved in two rehabilitation sessions of a counterbalanced design. In the voluntary contraction session, they performed 20 min of repeated active flexions of the impaired metacarpophalangeal joint. In the superimposed electrical stimulation session, they performed 20 min of percutaneous neuromuscular electrical stimulations which were superimposed to voluntary flexion.

Results. – Mean active range of motion improvement from pre- to post-session was significantly greater in the superimposed electrical stimulation condition compared to the voluntary contraction condition (11 ± 5 deg versus 3 ± 4 deg; $P < 0.01$).

Conclusion. – Superimposing electrical stimulation to voluntary contractions is an efficient technique to improve active range of motion of the pre-stiff metacarpophalangeal joint of the thumb.

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Keywords: Hand; Injury; Physical agent; Rehabilitation

Résumé

Objectif. – Cette étude avait pour objectif de tester l'efficacité de la technique d'électrostimulation surimposée sur la mobilité du pouce pré-raide après réparation chirurgicale d'une rupture du ligament collatéral ulnaire.

Matériel et méthodes. – Huit patients présentant une articulation métacarpo-phalangienne pré-raide ont participé à deux sessions de rééducation dans un modèle contrebalancé. Dans la session de contraction volontaire seule, les patients réalisaient 20 minutes de flexions actives de l'articulation métacarpo-phalangienne opérée. Dans la session de stimulation électrique surimposée, ils réalisaient 20 minutes de flexions de cette même articulation avec stimulation électrique transcutanée surimposée à la contraction volontaire.

Résultats. – L'amélioration des amplitudes articulaires actives pré- versus post-test était significativement supérieure dans la condition de stimulation électrique surimposée en comparaison de la condition active volontaire (11 ± 5 deg versus 3 ± 4 deg ; $p < 0,01$).

Conclusion. – Surimposer une stimulation électrique à la contraction musculaire volontaire est une technique efficace pour améliorer l'amplitude de l'articulation métacarpo-phalangienne de pouces pré-raides.

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Mots clés : Main ; Blessure ; Agent physique ; Rééducation

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1. English version

1.1. Abbreviations

MP	metacarpophalangeal joint
SES	superimposed electrical stimulation
UCL	ulnar collateral ligament
VAS	visual analogic scale
VOL	voluntary active contraction

1.2. Introduction

Rupture of the ulnar collateral ligament (UCL) of the metacarpophalangeal joint (MP) of the thumb, also called the skier's (acute) or gamekeeper's thumb (chronic), is frequently associated to injuries to the dorsal capsule, palmar plate, and adductor aponeurosis [1–3]. Post-surgically, the thumb is immobilized during 4 to 6 weeks [4,5] which increases the risk of stiffness [6–9]. As range of motion loss is an important factor for patient dissatisfaction with the outcome of UCL surgery [8], avoiding stiffness (i.e., a permanent loss of range) is a priority.

In rehabilitation, stiffness resulting from inflammation and adhesions [10] is one of the potentially incapacitating complications that often challenges therapeutic skills [11–14]. Joint mobilization has already proved to be efficient in preventing stiffness. Specifically, joint mobilization increases tensile strength of the wound [15], directs the alignment and orientation of collagen fibers [16], enhances tendon gliding [17], reduces tendon adhesions [18] and limits joint stiffness [19]. However, in some cases, adherences between tissues can remain despite the use of classical rehabilitative techniques. In this context, studies that have investigated the effects of electrical stimulation on range of motion recovery may be of interest [20,21]. Indeed, adhesions are mainly composed of collagen, a tissue whose resistance to gradual deformation by tensile stress (i.e., viscosity) depends on its previous history of length changes [22]. This mechanical property is defined as thixotropy [23]. As a consequence, artificially prolonging the stress imposed to adhesions would reduce their viscosity and result in greater deformation of this tissue. Clinically, it would prevent stiffness for a longer period of time thereby increasing

the possibility for recovering greater range of motion. The superimposed electrical stimulation technique [24,25], i.e., percutaneous electrical stimulation superimposed to a voluntary muscle contraction, has recently proved to prolong the muscle ability to repeat maximal contractions without altering force parameters over time [26].

Here, we intended to compare, for the first time, the effects of voluntary muscular contraction (VOL) and superimposed electrical stimulation (SES) on the range of motion recovery of pre-stiff MP of the thumb after operative repair of UCL. It was hypothesized that the SES technique would be more efficient than VOL to restore joint mobility of the thumb's MP joint.

1.3. Material and methods

1.3.1. Patients

Eight volunteers (age: 43 ± 12 years; 3 females) were recruited among patients who were undergoing treatment within a hand therapy center (Centre grenoblois de rééducation de la main et du membre supérieur, France) to resume functional use of their thumb after UCL surgery (different surgeons). Postoperatively, the involved MP joint was immobilized in a thermoplastic splint for 4 weeks [4]. After these 4 weeks, patients were allowed to start active gentle flexion/extension exercises [4]. Resistive work was started at 6 weeks [5,17,23]. To be included in the study, patients had to be between 20 and 65 years old. In addition, after 8 weeks post-surgery (61 ± 9 days) all patients who demonstrated a loss of range of motion in the injured MP of at least 10 deg (31 ± 9 deg) when compared to the opposite thumb and whose range was not improving anymore using classical rehabilitative techniques (i.e., pre-stiff patients) were included in the study. Exclusion criteria were a history of complex regional pain syndrome, peripheral vascular disease, peripheral neuropathy, central nervous system dysfunction, and diabetes. Features of the patient sample are reported in Table 1. Patients provided written informed consent and their rights were protected as required by the Helsinki Declaration (1964) and the local Ethics Committee.

1.3.2. Task and procedures

Patients were seated, their shoulder abducted approximately 15 deg and neutrally rotated, elbow flexed 110 deg, forearm in a

Table 1
Patients.

Patient	Age	Injury	Surgery	ROM deficit	Pain	Days post-surgery
1	35	Corporeal tear	Direct suture of the UCL to itself	29°	1.7	80
2	37	Stener lesion	Intraosseous suture anchor (Mitek)	20°	1.0	56
3	43	Distal tear	Direct suture of the UCL to the periosteum	30°	0.2	60
4	52	Stener lesion	Intraosseous suture anchor (Mitek)	22°	0.3	59
5	63	Proximal tear	Direct suture of the UCL to the periosteum	10°	0.0	54
6	50	Proximal tear	Direct suture of the UCL to the periosteum	15°	0.3	53
7	38	Distal tear	Direct suture of the UCL to the periosteum	16°	0.0	59
8	25	Proximal tear	Direct suture of the UCL to the periosteum	18°	0.1	70

UCL: ulnar collateral ligament; ROM deficit: pre-session difference in MP active flexion compare to contralateral thumb; VAS: mean of pre-session pain levels assessed with a visual analogic scale with 10 being the maximal value; number of days post-surgery on the first rehabilitation session.

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