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CHANGES IN CORTICAL RELATIVE POWER IN PATIENTS SUBMITTED TO A TENDON TRANSFER

A pre and post surgery study

Julio Guilherme Silva[1,2], Irocy Guedes Knackfuss[3], Cláudio Elidio Portella[1], Sergio Machado[1,2], Bruna Velasques[1,2], Victor Hugo do Vale Bastos[1,2], Ricardo de Andrade Queiroz[2], Marco Antonio Orsini Neves[4], Mariana Pacheco[2], Camila Ferreira Vorkapic[1], Mauricio Cagy[1,2], Roberto Piedade[1,2], Pedro Ribeiro[1,2]

ABSTRACT - The aim of this study is analyze possible modifications in the cerebral cortex, through quantitative electroencephalography (qEEG) in patients submitted to a tendon transfer procedure (posterior tibialis) by the Srinivasan's technique. Four subjects (2 men and 2 women), 49.25 age average (SD±21.4) were studied. All subjects have been through surgical procedure due to leprosy and had, at least, two years of drop foot condition. The qEEG measured the electrocortical activity (relative power) between 8 and 25 Hz frequencies pre and post surgery. A paired t test analyzed all data ($p \leq 0,05$). The results show significant alterations in the alpha relative power, electrodes F7 ($p=0.01$) and F8 ($p=0.021$). Altogether, based on findings of the current literature, we can conclude that the tendon transfer procedure suggests electrocortical alterations sensitive to specific qEEG bands.

KEY WORDS: qEEG, tendon transfer, relative power, drop foot, leprosy.

Alterações na potência relativa cortical em pacientes submetidos a transferência de tendão: estudo pré e pós-cirurgico

RESUMO - O objetivo deste estudo é analisar possíveis modificações no córtex cerebral, através da electrencefalografia quantitativa (EEGq), em pacientes submetidos a um procedimento de transferência de tendão (tibial posterior) pela técnica de Srinivasan. Quatro sujeitos (2 homens e 2 mulheres), com média de idade de 49,25 anos (±21,4 DP) foram estudados. Todos os sujeitos realizaram o procedimento cirúrgico devido a hanseníase e tinham, pelo menos, dois anos de pé caído. O EEGq mediu a atividade electrocortical (potencia relativa) entre freqüências de 8 e 25 Hz, no pré e pós-operatório. Um teste *t* pareado analisou todos os dados ($p \leq 0,05$). Os resultados mostram alterações significativas na potência relativa em alfa, nos elétrodos F7 ($p=0,01$) e F8 ($p=0,021$). Baseados em recentes achados na literatura, podemos concluir que o procedimento de transferência de tendão sugere alterações eletrocorticais sensíveis às freqüências específicas do EEGq.

PALAVRAS-CHAVE: EEGq, transferência tendinosa, potencia relativa, pé caído, hanseníase.

The peripheral neuropathy is one of the most important consequences of leprosy, because of the myelinization and demyelinization reactions that occur in the infection process by the *Mycobacterium leprae*[1]. Such nervous lesion promotes deficits in the motor and sensory systems, especially in hands and feet[2]. The deformities caused by the muscular unbalance in these corporal segments become a point of study for health professionals working with leprosy. In the orthopedics field, one of the procedures for treating this type of muscular impairment is the tendon transfer[3]. This surgical procedure objects the reestablishment of the segment functionality undergoing paralysis. In the thirties, Ober[4] accomplished the first surgeries for the correction of the paralyzed inferior member, through tendinous transfers. When muscular function is impaired by peripheral neuropathy due to leprosy, the tendon transfer procedure

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[1]Laboratory of Brain Mapping and Sensory-Motor Integration, Institute of Psychiatry, Rio de Janeiro RJ, Brazil (IPUB / UFRJ); [2]IBBN - Instituto Brasileiro de Biociências Neurais; [3]Department of Orthopedics, Medicine School (FM-UFRJ); [4]Department of Neurology Universidade Federal Fluminense, Niteroi RJ, Brazil.

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Dr. Julio Guilherme Silva - Rua Filgueiras Lima 68 / 104 - 20950-050 Rio de Janeiro RJ - Brasil. E-mail: jgsilva@hucff.ufrj.br

most frequently utilized is the one that uses the tibialis posterior muscle. It is also often indicated in the cases of peroneal nervous lesions, which causes the drop foot. Srinivasan[5] has developed the most utilized posterior tibialis tendon transfer technique. The aim of this procedure is to restore active ankle dorsiflexion[6]. Few investigations observed the re-learning of the movements after transfer procedures, especially through quantitative electroencephalography (qEEG) analysis of the possible cortical alterations between the pre and post operative times[7,8].

Some experiments have tried to elucidate the dynamics of cortical activity when individuals incorporate motor procedures[9,10]. However, such investigations aiming at explaining the neuroplasticity mechanisms during the processes of functional recovery and motor re-learning of the dorsiflexion are still scarce. Particularly in patients submitted to tendon transfer for drop foot, as function of leprosy[8]. Osman et al.[11] analyzed the cortical lateralization paradigm during imagination of feet movements. During the task, subjects had to imagine the hands and feet moving randomly. The results showed that the task of imagining movements was not related to the lateralization paradigm, although, paradoxically, while imagining feet movements, they observed an activity increase in somatossensory areas. This suggests that imagining and actually elaborating movements produces muscular activity[11]. In EEG studies, alpha and beta ranges are related to activities in the somatossensory cortex and novelty learning process. Some investigations have demonstrated the correlation between the alpha band (8-13 Hz) and cognitive aspects such as attention while performing or re-learning a motor task[12,13]. The beta range (13-30 Hz) has a direct relationship with motor and somesthesia processes[14]. For this reason, the aim of this study was to analyze, through qEEG, possible modifications in the electrocortical activity, specifically in the alpha and beta bands/ranges, in patients submitted to the tibialis posterior tendon transfer.

METHOD

Sample – Four subjects were selected (2 men and 2 women). They were patients from the service of Orthopedics and Traumatology of the Hospital Universitário Clementino Fraga Filho / Universidade Federal do Rio de Janeiro (HUCFF/UFRJ) with drop foot due to leprosy. All subjects had a lesioned in the right foot and lacked both dorsiflexion and eversion movements. The age of the patients varied from 20 to 71 years (average 49.75 / SD±21,4). A questionnaire was given in order to identify and exclude subjetcs. An anamnesis identified biological determinants that could alter qEEG, such as: fatigue, medication, hours of sleep, body temperature, and blood pressure. Subjects were instructed not to smoke, drink coffee and caffeine or xanthine-containing soft drinks, not to ingest alcohol at least for 10 hours before the exam and have at least 8 hours of sleep. Subjects who had suffered previous physiotherapeutic and orthopedical treatment for correction of the drop foot were excluded from the study. Other exclusion criteria were: plantar ulcers and rigid deformities of the foot, motor deficits or use of psychotropic or psychoactive drugs. The entire experimental protocol was approved by the Research Ethic Committee of HUCFF / UFRJ under the number 228/04 with CIC 193/04.

Experimental protocol – Electroencephalographic analysis observed the possible modifications in the electrical activity between the pre and post surgery times. Two signal acquisition phases were considered for the development of this experimental design. The pre operative phase consisted of a qEEG of five blocks and ten trials, during which, each subject tried to accomplish a dorsiflexion movement in the paralyzed foot. After the surgical intervention, all subjects were immobilized for 6 weeks. At withdrawal of imobilization the subjects were submitted in the same day, a second qEEG was performed while subjects attempted to make the same movement. At the pre and post surgery phases, the electroencephalographic analysis had a total duration of 20 minutes, 10 minutes with eyes open and 10 minutes with closed eyes. The task (dorsiflexion) was done in 5 blocks of 10 movements for each condition (open eyes/closed eyes). Pre surgery phase scalp signals were captured when the investigator requested the subjects to perform the task and post surgery was synchronized by a goniometer which marks the qEEG data. Two-minutes of interval were given between blocks to avoid muscular fatigue. To mark the beginning of the dorsiflexion movement, it was stipulated that the task would begin after the examiner touches the lateral part of the subject's left forearm. All subjects accomplished the dorsiflexion movement at the maximum of the limit range.

Thigh and leg areas were supported in their posterior phases so that the foot was in suspension and the knee extended, placing the foot in a neutral position. The goniometer was fixed to the ankle, respecting all anatomical points for its placement, as follows: the superior arm of the goniometer placed in the border of the fibula, and the inferior one put at the external border of the foot, aligned the diaphysis of the 5th metatarsus. In the central axis of the goniometer, located laterally on the ankle, a potentiometer was coupled to the EEG device, enabling the observation of the movement onset. In the experiment, the goniometer simply registers the dorsiflexion movement and does not consider the degree precision of the articular amplitude. For the quantification of functional analysis, we adapted the evaluation model of tendon transfers proposed by Yeap[15]. The questionnaire was composed of 7 categories with different values which are: pain, need of orthesis, normal shoes, functional outcomes, muscle power, degree of active dorsiflexion and foot posture.

Data acquisition – Electroencephalographic data were captured in a prepared, sound and electric isolated room.

During the acquisition of the signs, lights were reduced to minimize visual artifacts. Subjects sat down comfortably in a chair with arm supports, reducing the action of the muscular devices in the reception of the EEG sign. A Braintech 3000 (EMSA - Medical Instruments, Brazil) device was used to acquire all electroencephalographic data. This system uses an analogical-digital converter plate (A/D) of 32 channels, 12 bit resolution, put in a slote ISA of a Pentium III processor of 750 Hz. For the electrodes, a cap whose placement obeys the international10-20 system was used, including the electrodes of both auricular references[16]. The size of the cap used accorded to each subject's cranial perimeter (caps of varied sizes). The electrophysiological signs were filtered between 0,01 (pass-low) and 100 Hz (pass-high) having a sample tax of 200 Hz. The software for acquisition is called EEG-reception (Emsa-DELPHI 5.0), with a filter Notch of 60 Hz, and yet filters with cut of 0.3 Hz (pass-high) and 25 Hz (pass-low). The sign acquired in a specific electrode will be the result of the difference between the electrical potential of the scalp and the pre-established reference. All electrode impedances were kept below 5 kΩ. The signal was amplified with a gain of 22.000, analogically filtered between 0.01 Hz (high-pass) and 100 Hz (low-pass), and sampled at 240 Hz using a Braintech-3000™ (EMSA-Medical Instruments, Brazil) EEG acquisition system. The EEG was recorded by means of the software *ERP Acquisition* (Delphi 5.0™, USA), developed at the Brain Mapping and Motor Sensory Integration Lab - Universidade Federal do Rio de Janeiro, employing the following digital filters: *notch* (60 Hz), high-pass of 0.3 Hz and low-pass of 30 Hz.

The signals acquired (peak to peak) were smaller than 100 μV (total amplitude). The parameters of qEEG were extracted corresponding to the dorsiflexion movement phases before and after the tendon transfer surgical procedure. Muscular artifacts were extracted as followed: (1) visual inspection to guarantee a specific selection of the valid passages, and (2) an automatic algorithm device rejected all values beyond 100 μV. Subsequently, EEG signals were processed by the Neurometrics Program (NxLink, Ltd., USA), which calculated relative power measures from alpha and beta bands.

Spatial location of electrodes and frequency bands - In this study frontal and parietal electrodes were selected. The frontal area was detached due to the relation of these with the motivation processes, task organization and attention at execution of the voluntary movement[17,18]. The inclusion of parietal electrodes justifies by sensorial control and space mechanisms that occur in such area[19]. Based on these evidences, for this experiment the pairs of electrodes F3-FZ, F7-FZ, F8-FZ, F4-FZ, P3-PZ, P4-PZ at relative power of the alpha and beta bands (8-30 Hz) were selected.

Statistical analysis - Since electrodes occupy a space position differentiated in the scalp, we opted for an independent statistical analysis. EEG data were measured in two different times: before and after the surgery. All data were previously log transformed ($\log_{10}$) and statistically analyzed by a paired *t*-test.

RESULTS

The results obtained were divided into 2 categories: behavioral and electrophysiological.

In the present experiment, statistical analysis demonstrated a significant difference between the two experimental times (pre and post surgery) in the alpha band, in electrodes F7 (p=0.01) and F8 (p=0.021). The Figures 1 and 2 show the electrophysiological outcomes for the alpha frequency band. No significant results were found at beta band.

DISCUSSION

The present study aimed at observing electrocortical changes after the tendon transfer surgery. Essentially, behavioral and cortical modifications were expressed in terms of Yeap[3] and alpha relative power, respectively. The behavioral variable included motor performance, while electrophysiological variables, represented by the qEEG, examined electrocortical alterations.

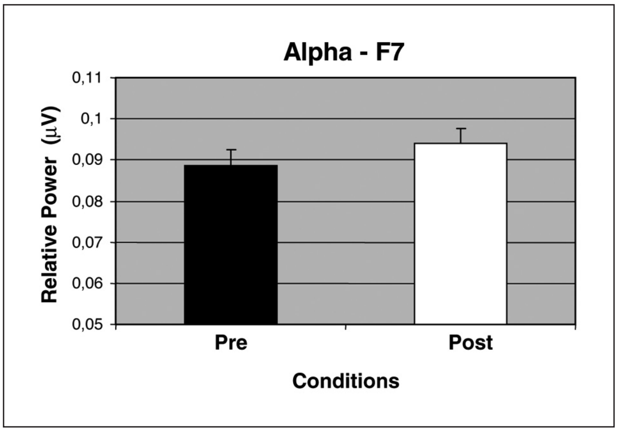

Fig 1. Alpha relative power variation before and after the surgery, in the F7 electrode.

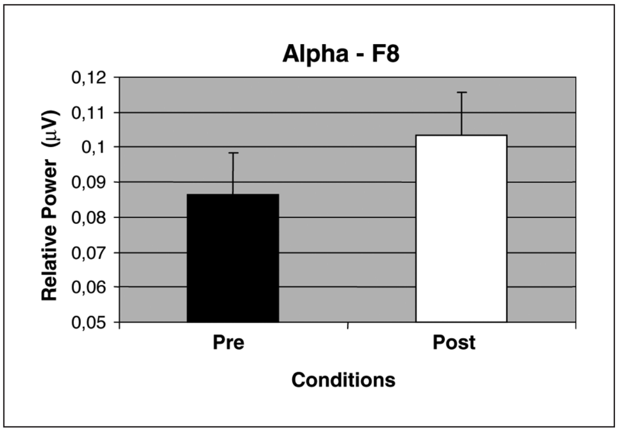

Fig 2. Alpha relative power variation before and after the surgery, in the F8 electrode.

Behavioral results (dorsiflexor function) - Several studies nowadays have shown that the tibialis posterior tendon transfer produces significantly functional results in the treatment of drop foot[3,8,15]. In the present study, subjects were analyzed by the functional evaluation Yeap scale for tendinous transfers, before and after the surgery. Half of the subjects were classified as "good" and the other half as "poor", for functions of daily activities before the surgery. After the surgery, even with edema and hypotrophy of the posterior muscular group of the leg and the transferred muscle, subjects considered the surgery's initial result as satisfactory, especially concerning the capacity to make the dorsiflexion movement again and foot positioning. Therefore, according to the Yeap scale, two subjects developed from "good" to "excellent" even with some small functionary marching deficits and two subjects developed from "poor" to "good".

Usually after the surgery, subjects tend to lose some degree of muscular power. Due to the lesion characteristics, the mechanisms of re-establishment of the dorsiflexion function express the motor relearning process. This consolidation needs proprioceptive information which is integrated to other internal sensorial inputs. These inputs are obtained from previous experiences like specific task memories and formation of new motor patterns[18]. In the tibialis posterior tendon transfer, the dorsiflexion is present, even in small movement degrees. It is at an angle great enough to promote pace function improvement. Some studies have demonstrated that the ankle can be considered a functional unit when it comes to walking, with a dorsiflexion mean of approximately 6 to 10 degree[3]. Although the surgery presents good results regarding the foot dorsiflexion function, it might act better when a concomitant post surgery physiotherapeutic program is initiated. Through specific exercises to gain range of motion and muscular power, the gait can also have benefits.

Electrophysiological results (qEEG and motor relearning) – According to our results, an increase in alpha relative power in the electrodes F7 and F8 (Figs 1 and 2) was observed. The alpha band is an important qEEG variable, representing general demands of effort when performing a task with some level of activation, attention and cognition[20]. Specifically, there is an inversely proportional relationship between alpha power increase and activation level of the involved area[13]. The results indicate that the tendon transfer procedure and the return of the dorsiflexion function promote electrocortical alterations. The alpha power increase in F7 electrode might represent a neuronal specialization that occurred after the tendon transfer procedure; suggesting a greater mental effort and attention in an attempt to perform the new movement[20]. In addition, it might be considered a pre learning stage[21]. Our outcomes are in agreement with neuroplasticity theories, regarding the motor restoration mechanisms of foot movement after the surgery. Experimental models have proved the consolidation of retaining specific information arriving from motor tasks by synapitic modifications[22]. A few investigators affirm that the dorsiflexion movement itself activates several motor areas representing specific muscular groups involved with gait[23,24]. Recent fMRI demonstrated that at the moment of dorsiflexion movement, the contralateral areas of the primary motor cortex, supplementary motor area, ipsilateral thalamus, basal ganglia, prefrontal cortex and ipsilateral cerebellum are all active in healthy individuals[23].

The alpha relative power increase in the F8 electrode, situated in the contralateral motor cortex of the active member during the task to the responsible for the task, seems to represent an intrinsic process of cortical activity modulation. Therefore, we have concluded that the results indicate an integration processes between the planning areas of the right (F8) and left (F7) hemisphere. It is possible that such effects result of an alteration in the activation state, due to neuronal deactivation of the motor area regarding the hemispheres[25]. Consequently, the alpha relative power increase in the F8 electrode suggests a reduced neuronal recruitment processing the activity in such hemisphere. Neurons of the right hemisphere might be in state of readiness, possibly due to cognitive and sensory processes, and neurons of the left hemisphere could be involved in the planning task[18]. Hence making the cognitive and sensory aspects influence the oscillation of alpha power in the motor areas. Experimental models attribute alterations in the somesthesic inputs, which occur during the task to proprioceptive impulses. The somatossensory parameters related to the foot are essential for the motor planning improvement. A few experiments have demonstrated that such proprioceptive mechanisms are specific of these somatossensory cortical areas, specifically, hands and feet[25-27]. However, the real meaning of cortical activity changes is still far from being elucidated[28].

Regarding the cognitive aspects, the alpha relative power increase in the right hemisphere might be due to a higher attention level for the accomplishment of the dorsiflexion movement; indicating that cognitive aspects can influence modulations of such a specific movement in the postoperative phase[29]. Even with neuroimage progress, just a few experimental models have been formulated to discuss the real alterations of the sensory-motor areas immediately after the surgery, focusing, instead, on specific rehabilitation therapies[24,30]. Such a model might fill out the emptiness in the literature concerning the functional recovery and the neuroplastic processes.

Based on the present findings, it is not unreasonable to conclude that the tendon transfer procedure itself promotes electrocortical alterations, although future studies on distinct neural plasticity investigations before and after such surgical procedure, are still needed to replicate these outcomes, specifically during functional recovery and motor re-learning programs on patients suffering from droop foot due to leprosy.

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