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## **Integrating and monitoring hand burn rehabilitative treatment using Virtual Reality**

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**ABSTRACT.** *Hand burn is not a common condition in the clinical practice and needs a long and laboured rehabilitative treatment to restore the lost function. This case report illustrates the achievable improvements in mobility and function by using innovative inertial systems for occupational exercise in a Virtual Reality, in addition to a traditional rehabilitative treatment. Through these instruments, we could promote and concurrently assess the recovery of a functional grasp and the ability in the execution of Activities of Daily Living.*

**Key words:** occupational therapy, burn, hand, virtual reality.

**RIASSUNTO. INTEGRAZIONE E MONITORAGGIO DEL TRATTAMENTO RIABILITATIVO DI UN'USTIONE ALLA MANO ATTRAVERSO L'USO DELLA REALTÀ VIRTUALE.** *Un'ustione alla mano non è una condizione di frequente riscontro nella pratica clinica e, inoltre, richiede un percorso riabilitativo lungo e complesso al fine di ottenere un recupero della funzionalità persa. Questo case report illustra i miglioramenti, in termini di mobilità e funzione, raggiungibili attraverso l'uso di innovativi sistemi inerziali dedicati all'esercizio occupazionale in un contesto di Realtà Virtuale, in aggiunta a un trattamento riabilitativo tradizionale. Attraverso questi strumenti, è stato possibile ottenere e, allo stesso tempo, quantificare il recupero della presa funzionale e, in generale, dell'abilità nell'esecuzione delle più comuni attività, restituendo al paziente l'indipendenza nella sua vita quotidiana.*

**Parole chiave:** terapia occupazionale, ustione, mano, realtà virtuale.

### **Introduction**

Burn consequences can be more or less disabling, depending on the extension of the cutaneous surface and on the corporeal district involved. Hand burns deserve a particular clinical attention, because of the risk of a permanent functional limitation. According to literature (1), the traditional rehabilitative treatment consists in active and passive physiotherapy, to recover motility and function. Another therapeutic resource is represented by instrumental physical therapies based on mechanical energy, such as ultrasound and shock wave therapies, which promote tissue regeneration (2, 3).

To restore hand function after a burn, we propose the integration of a traditional rehabilitative approach with the innovative introduction of an inertial system for occupational exercise in a Virtual Reality (VR).

### **Case presentation**

A male patient aged 54 came to our observation in March 2014, with his left hand showing, on the dorsal side, signs of II and III grade flame burn, occurred in a domestic environment in January 2014. In the acute phase, the patient underwent a surgical intervention of cutaneous graft in the de-epithelized area. At our first observation (Figure 1-1), he presented with a non-functional left hand due to scar tissues. Patient's left hand was almost motionless, with a range of movement (ROM) limited to the first degrees of flexion and extension in the metacarpophalangeal (MCP), proximal (PIP) and distal interphalangeal (DIP) joints and with a ROM limited to 45° of wrist flexion and few degrees of wrist extension. The patient signed an informed consent for the rehabilitative treatment and the video recording procedures.

According to the most recent literature (1), we started motor re-education to recover the ROM, consisting of active-assisted kinesiotherapy and stretching associated to scar massage to promote the relaxation of fibrous tissues. During the first four months, we planned the treatment with a daily frequency, then twice a week for the following twelve months. Overall, 9 cycles of physiotherapy, each composed by 10 sessions, were completed. Six months after the burn, having obtained a progressive partial delimitation of the scar tissues, we integrated the rehabilitative program with ultra-



**Figure 1. Clinical improvement over time**

1 - First clinical observation (March, 2014). 2 - Nine months from the burn (September, 2014). 3 - Fist closure and 4 - Skin improvement at the last rehabilitative session (June, 2015).

sound therapy in a pulsed form, daily supplied for 5 consecutive sessions (frequency = 1 MHz, intensity =  $0.7 \text{ W/cm}^2$ ) (2). Then, one year after the lesion occurred, persisting the need to improve trophism of the residual scar tissue (in the terminal phase of reorganization), we prescribed 3 sessions of extracorporeal shock wave therapy, administered with defocalized modality (frequency = 3 Hz, pulses =  $350/\text{cm}^2$ , intensity-EFD =  $0.05 \text{ mJ/mm}^2$ ) once a week for 3 weeks (3).

Throughout the rehabilitative treatment, we performed, once a month, 5 occupational therapy sessions in the form of Virtual Reality (about 20 minutes per session) with a modular net of inertial systems supported by a dedicated software, Technobody Motion Analysis® 1.0 (version code: TMA-MANSW-01), to train the prehensile function. Specifically, we used the module called Occupational Therapy, which included three different sections: *Kitchen*, *Cleaning*, *Table*. Each session required the execution of finalized tasks in a domestic environment. Depending on the section, the patient

was asked to modify the disposition of various objects in a kitchen environment: cleaning a window surface, positioning some objects on overlapping levels or from one side of a table to another. The virtual grab was obtained through the grip of the patient's hand around a pump with a pressure sensor inside. The recovery of this specific ability was particularly important in our case, as the loss of the prehensile function was the most penalizing aspect. The program evaluated the time employed by the patient to perform each section and the number of the completed tasks within each session, in order to estimate coordination, dexterity and visual-motor abilities. Errors were not considered because the patient showed from the beginning a moderate precision (about 90%), despite the prehensile impairment (Figure 2).

During the follow-up, we verified a gradual improvement in mobility and hand function. At the end of the rehabilitative treatment, we observed only a residual ROM limitation in the III and the IV finger PIP flexion (Table I); we also measured the distance between the top of the II-V fingers and the palm at the maximum active flexion, finding 2 cm for II, 3 cm for III, 2.5 cm for IV and V fingers (4).

Finally, we obtained an almost complete fist, with adaptations for objects of diameter less than 2 cm, and a further improvement in the scar trophism (Figure 1, 1-4). A quantitative measure of the manual strength improvement was obtained using the Handgrip Dynamometer: at the beginning of physiotherapy, the patient was unable even to hold the instrument, whereas at the last session we registered a value of 28.5 kg (mean of three consecutive measurements,



**Figure 2**

**Table I. Progressive improvement in joint mobility (flexion) during follow-up**

	March 2014	April 2014	May 2014	June 2014	July 2014	September 2014	June 2015
MCP	10°	20°	30°	45°	60°	90°	90°
PIP	10°	45°	75°	80°	90°	100°	105°
DIP	10°	45°	80°	90°	90°	90°	90°

MCP = metacarpophalangeal joints; PIP = proximal interphalangeal joints; DIP = distal interphalangeal joints.

**Table II. Improvement in Hand Functional Disability Scale during rehabilitative treatment**

	Kitchen	Dressing	Hygiene	Office	Other	Total
March 2014	40	10	10	10	20	90
January 2015	5	2	2	2	2	13
June 2015	2	1	0	0	0	3

SD=0.86). This result can be placed beyond the tenth percentile of the normality range for healthy male subjects (5). Considering the results obtained during VR sessions, from April to December 2014, we observed a clear reduction of the time needed to complete each section and an increase in the number of completed actions. In the modality *Kitchen* the time spent to complete the task reduced from 76" to 35". In the modality *Cleaning* the time spent to complete the task reduced from 71" to 37". In the modality *Table* we considered the time employed to position a single object, that reduced from 9,2" to 5,7". We could also assess an improvement in hand function through the "Hand Function Disability Scale", a questionnaire composed by 18 items, with a score of 0 - 5 on the basis of an increasing order of difficulty (6). The score effectively improved from 90/90 (2014 March) to 3/90 (2015 June), with persistence of a tolerable motor hindrance in activities as slicing meat, peeling fruit or buttoning up a shirt (Table II).

As we previously introduced, we observed a gradual improvement in mobility and hand function during the whole follow-up. In the present case, the improvements observed by the means of the clinical and functional measures and those recorded during the VR sessions revealed collinear over time. To our knowledge, no data are actually available in medical literature that correlate clinical and functional measure in case of hand burn. It would be interesting to statistically correlate this different kind of measures, extending the sample in the immediate future.

## Discussion

In our case, we achieved a critical improvement in hand mobility and function after a hand burn. Our patient became gradually able to recover an almost complete fist and to increase manual coordination and speed, restoring his independence in ADL after an assisted rehabilitative treatment.

We used VR, not just to recover the functional autonomy, but mainly to monitor the rehabilitation pathway, providing a feedback both to the physician and to the first actor of the rehabilitative scene: the patient. The therapeutic rationale for using technology in rehabilitation include the option of repeating exercises with success and feedback, the ability to use motivating exercises, and the fact that feedback and success improve motor learning (7, 8).

In literature, there are no systematic reviews about the use of computer-based activities or VR technology in hand rehabilitation, excepting some reviews in the field of neu-

rological disorders (9). A review by Burridge and Hughes in 2010 (10) showed that the use of technology per se is not superior to therapy, but it can provide more intensive training and show improvement in function beyond the normal recovery period. About the same topic, Jarus et al (11) did not find significant differences, but found significant satisfaction for the patient with the use of technology.

Which are the best interventions to recover the function of upper limb? Currently, evidence is insufficient to enable comparison of their relative effectiveness. A recent Cochrane systematic review showed moderate-quality evidence of a beneficial effect of both virtual reality and a relatively high dose of repetitive task practice, suggesting that these may be effective interventions in functional recovery of the upper limb after stroke (12). In conclusion, the use of innovative computerized equipment could enhance therapy results and increase participant's satisfaction throughout the long duration of hand rehabilitation.

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