

FEATURES OF MIRROR VISUAL FEEDBACK APPLICATION FOR PATIENTS WITH PHANTOM LIMB PAIN IN THE PRESENCE OF ATYPICAL PHANTOM POSITION



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One of the most interesting methods of neurorehabilitation is Mirror Visual Feedback (MVF). Despite the widespread information about effectiveness of MVF, specialists who have previously used this method but have not achieved positive results when working with patients, have many questions about the specific features of its application.

Objective. The aim of our study was evaluation of the MVF effectiveness for reducing the severity of phantom pain in an amputated limb in the presence of atypical phantom location.

Material and Methods: The study involved 29 patients with phantom limb pain. The severity of pain and quality of life were assessed.

Results: It was found that the effectiveness of the MVF depends on some important factors, such as a discrepancy between the location of the phantom at the level of sensations and in reflection, duration and severity of the pain syndrome.

Conclusions. An important factor in the successful results of the MVF application is assessment of the initial position of the phantom and ability to change its position in space at the sensory level.

A decrease in the severity of phantom pain can create in the long-term the illusion that the patient has adapted to the problem.

The timing and frequency of the MVF course should be selected individually, depending on the duration, severity of phantom pain and patient fatigue.

It is assumed that the use of MVF in the early period after amputation prevents the development of phantom pain, which requires further research in this direction.

Keywords: Phantom limb, amputation, pain, rehabilitation

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Introduction

One of the most effective directions in complex medical rehabilitation of patients with diseases of the nervous system is biofeedback therapy, during which the patient receives information about the state of physiological processes in their own body through an external feedback loop. One of these methods is Mirror Visual Feedback - MVF [1, 2].

In the process of observing our own reflection in the mirror, we see ourselves in the opposite direction. However, if we turn the mirror ninety degrees and stretch our hand forward, we can see how one side of our body is reflected, creating the illusion that it is the other side, which happens due to the almost perfect symmetry of the human body along the sagittal midline. This "mirror illusion" has recently been widely used for the rehabilitation of neurological patients [2]. For the first time, this method was presented by the director of the Research Center for Higher Nervous Activity, professor of psychology and neurophysiology at the University of California Vilayanur S. Ramachandran, for the treatment of phantom pain in 1995 [2-13]. It is believed that MVF is an easy-to-use, inexpensive and effective method for improving the function of

the upper limb, during which the patient experiences an illusory perception of limb movement associated with the movement of the opposite limb by observing its reflection in a mirror [2, 5, 14-16].

By projecting the reflection of the intact hand onto the phantom limb using a mirror, patients reported that they can move and relax the phantom hand, and also noted a stable decrease in pain [2-4, 6, 15- 22].

Considering the non-invasiveness of the method, the minimal risk of side effects and the cost-effectiveness of the procedure, as well as the positive results of efficacy studies, the use of MVF is justified [23]. The inclusion of MVF in a standard medical rehabilitation program, both at an early stage of treatment and over a long period of time, can be useful for improving results of medical rehabilitation [1].

Despite the widespread information about the effectiveness of MVF up to now, specialists who have previously used this method but have not achieved positive results when working with patients, have many questions about the features of the application, which leads to the formation of doubts about the claimed effectiveness [4].

The aim of the study was to evaluate the effectiveness of using the Mirror Visual Feedback technique described in the literature to reduce the severity of phantom pain in an amputated limb.

Material and methods

The study involved 29 patients with phantom pain in the amputated limb.

The first part of the study involved 22 patients. Amputation of a limb occurred due to cancer in 8 patients, in 2 cases amputation was associated with complications of diabetes mellitus and in 12 cases amputation was a consequence of trauma. Of these, the course of MVF therapy was carried out in 7 patients in the period less than a month after amputation. In the second part of the study, 18 patients took part, of whom 9 received the MVF course in the first part of the study and 9 patients who had not previously received MVF therapy. Amputation of a limb occurred due to cancer in 7 patients, in 1 case amputation was associated with complications of diabetes mellitus, in 10 cases amputation was a consequence of trauma. Of these, the course of MVF therapy was carried out in 6 patients in the period less than a month after amputation.

The Categorical Verbal Scale (VRS) was used to assess the severity of pain. The Short Form Medical Outcomes Study (SF-36[®]v.2) questionnaire was used to assess the quality of life.

Statistical analysis of the data was carried out using the licensed software package Statistica 10.0 (AXAR207F394425FA-Q). In addition, to carry out the analysis by methods not presented in the Statistica 10.0 application package, we used the multi-paradigm interpreted programming language "R" (GNU GPL 2) in the form of a free open source computing environment.

To assess the unidirectional change in the value of a feature in two related samples, the criterion of signs was used; the assessment of the statistical significance of the differences between two relative indicators characterizing the frequency of a feature having more than two values was carried out using the Pearson Chi-square test. Fisher's exact test was used to compare two relative indicators characterizing the frequency of a feature, and a multinomial test was used for repeated measurements of this indicator.

The accepted threshold of statistical significance is $p < 0.05$. The analysis results are presented as a median and 25 and 75 quartiles (Me (25%; 75%)).

Results and discussion

From 2013 to 2015, patients participated in the first part of the study. Pain was assessed prior to the study.

It should be noted that the majority of patients with a duration of phantom pain persistence for more than one year assessed pain as less pronounced in comparison with patients in whom amputation occurred recently (Fig. 1).

However, in the course of a survey on the effect of phantom pain on self-care and quality of life, it was found that the elements of self-care, social

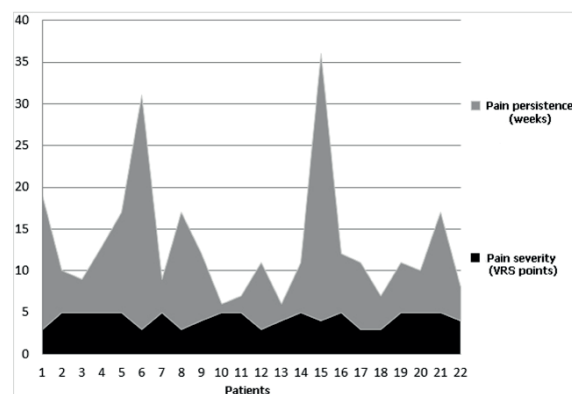


Figure 1. – Assessment of the severity of phantom pain and the duration of symptom persistence in patients before the start of the MVF course

functioning and quality of life are equally reduced in all patients.

To conduct the MVF session, the intact limb was positioned on one side of the mirror so that the reflection created the illusion of the second intact limb located on the opposite side, after which the patients were asked to squeeze and unclench the fingers, flexion and extension in the wrist and elbow joints (for the upper extremities) (Fig. 2) or ankle and knee joints (for the lower extremities), and rotational movements were also performed (Fig. 3).



Figure 2. – Example of upper limb movements



Figure 3. – An example of movements in the lower limb

The duration of the session was, on average, 20 minutes, 3 times a day; the duration of the course was 15 days. The group showed significant positive dynamics ($p < 0.001$) (Fig. 4).

Stable positive dynamics were observed in 8 patients. In 6 patients, there were no dynamics, and in 8 cases, phantom pain increased significantly 6-8 days after the completion of the MVF course ($p < 0.05$).

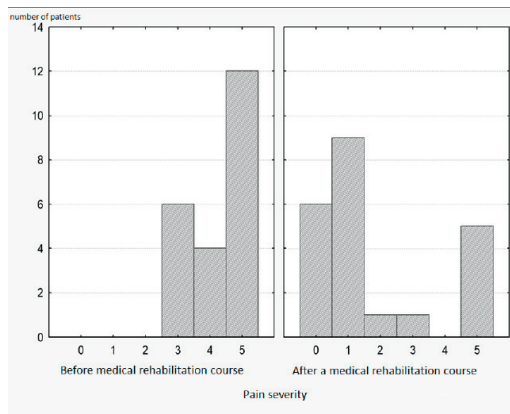


Figure 4. – Analysis of the dynamics of the severity of phantom pain in the process of using MVF (Sign-test)

A detailed study of the anamnesis, symptoms, and the underlying disease, revealed that in all cases with persistent positive dynamics, the time interval between amputation and MVF sessions did not exceed 1 month. In patients without dynamics, it was found that the position of the reflected limb did not correspond to the position of the phantom and, in the process of work, led to a discrepancy in the sensory perception of the limb in the mirror, and in some cases, after the first sessions, an increase in pain was noted (Fig. 5). In addition, it was found that the position of the phantom was often described as atypical, with a pronounced uncontrolled tone of the flexor muscles.



Figure 5. – Inconsistency of the phantom with the sensory response (on the left - the location of the intact limb and an attempt to give an identical position to the phantom; on the right - the perception of the location of the phantom at the sensory level)

Also, in some cases, a discrepancy at the level of sensory perception occurred due to the fact that the reflection in the mirror was distorted by an increase or decrease in the angle of the mirror on the surface (Fig. 6).

The information obtained at the first stage of the study made it possible to form a hypothesis that the effectiveness of MVF depends not only on the performance of simultaneous movements in the limb and the phantom, but also on other important factors, such as the duration and severity of the pain syndrome, the discrepancy between the location of the phantom at the level of sensations and in reflection.

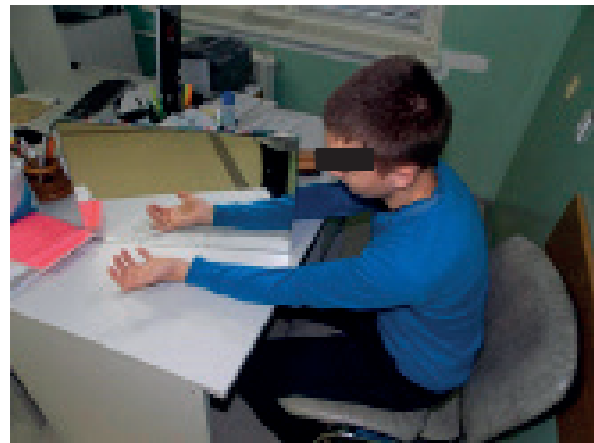


Figure 6. – Inconsistency of the ratio of reflection in the mirror with the real environment

In the second part of the study, 18 patients took part, of which 9 patients were participants in the first part of the study, without positive dynamics or in whom pain in the phantom returned after a short time (Fig. 7).

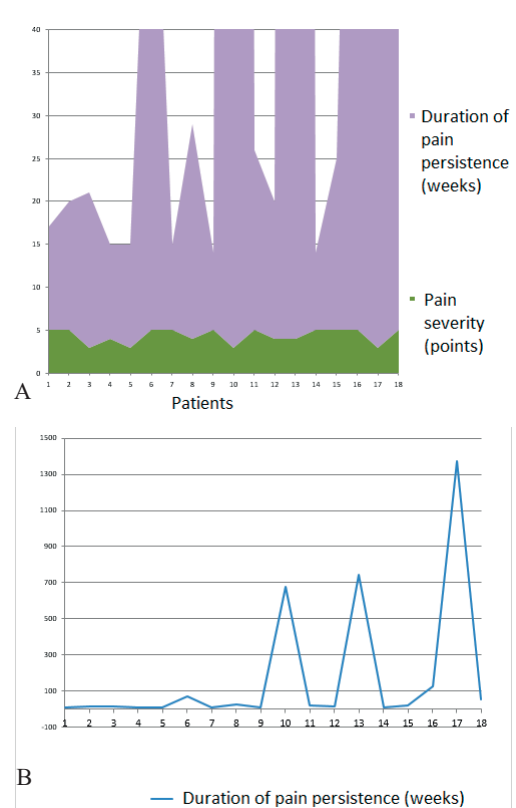


Figure 7. – Assessment of the severity of phantom pain and the duration of the symptom persistence in patients before the start of the MVF course (A - the ratio of the duration of the symptom and the severity of pain; B - the duration of the persistence of pain, expressed in weeks)

Also, in the second part of the study, patients with phantom pain lasting more than ten years took part.

Before starting work, the position of the phantom was determined. Subsequently, this information was used by a specialist to correct the position of the

limb with the patient's confirmation of the presence of a sensory response. Correction was carried out by giving the intact limb a position identical to the phantom with muscle tension (Fig. 8).



Figure 8. – Giving the intact limb an identical phantom position with muscle tension

After that, the specialist grasped the intact limb with one hand from the visible side of the mirror, the other hand was positioned so that the illusion of grasping the second limb was created in the reflected side of the mirror (Fig. 9).

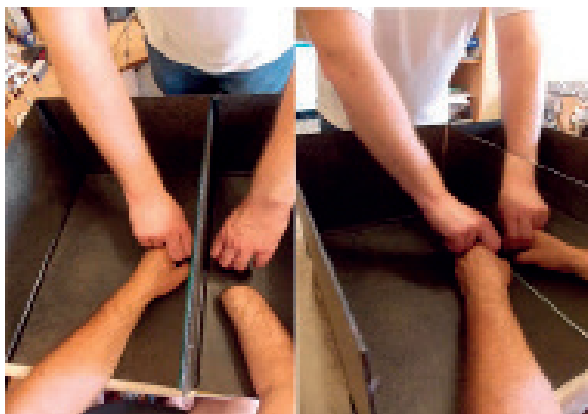


Figure 9. – Grabbing of a limb by a specialist before starting MVF training (on the left - the location of the limbs in reality; on the right - the location of the limbs in the reflection)

Then, under the control of sensations, kneading of the intact limb in the initial position was carried out, followed by slow extension in the joints. In the process of extending the limb, it is necessary to clarify with the patient whether the phantom feels identical to the reflection. If the sensations in the phantom do not correspond to the reflection, it is necessary to correlate the intact limb in such a way that the sensations of the phantom's position in space correspond to the position of the reflection of the intact limb. After giving the limb and the phantom a position accessible for work, it is necessary to once again clarify the correspondence of sensations to the observed reflection in the patient and then proceed to perform movements: flexion-extension in the joints, pronation-supination, in which the most pronounced pain sensations were previously observed (Fig. 9).

The duration of the initial sessions was selected individually and depended on the initial state of the patient and the feeling of fatigue in the trained limb, but subsequently increased to a time of no less than

15 minutes and no more than 30 minutes 3 times a day. The duration of the course was 2 weeks.

After completion of the study, positive dynamics were established in all patients ($p < 0.0001$) (Fig. 10).

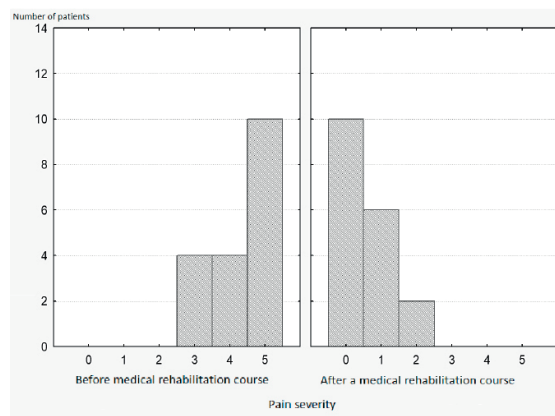


Figure 10. – Analysis of the dynamics of the severity of phantom pain in the process of using MVF (Sign-test)

One week after the completion of the rehabilitation course, three patients showed a slight increase in phantom pain. After a second two-week course, after a 10-day break, the pain was significantly relieved.

It was found that the use of MVF in patients in the first days after amputation prevents the formation of phantom pain, and in one patient, MVF showed positive results in the process of adaptation to a bionic prosthesis.

Conclusions

The results of the research work carried out made it possible to assess individual characteristics of the process of applying Mirror Visual Feedback in patients with phantom pain, to present a variant of the sequence of application of the method, taking into account the atypical location of the phantom, and allowing the following conclusions to be drawn:

1. The initial position of the phantom and the ability to change its position in space at the sensory level has a significant impact on the result of the course of Mirror Visual Feedback.

2. The severity of phantom pain in patients in the long-term period is significantly lower in comparison with patients in whom amputation has occurred recently, which, however, does not lead to an increase in the quality of life and social functioning.

3. The duration and frequency of Mirror Visual Feedback courses are selected depending on the duration, severity of phantom pain and patient fatigue.

4. It is assumed that the use of Mirror Visual Feedback in the early period after amputation, prevents the development of phantom pain.

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ОСОБЕННОСТИ ПРИМЕНЕНИЯ ЗЕРКАЛЬНОЙ ВИЗУАЛЬНОЙ ОБРАТНОЙ СВЯЗИ У ПАЦИЕНТОВ С ФАНТОМНЫМИ БОЛЯМИ В КОНЕЧНОСТЯХ В УСЛОВИЯХ АТИПИЧНОГО ПОЛОЖЕНИЯ ФАНТОМА

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Один из наиболее перспективных методов нейрореабилитации – зеркальная визуальная обратная связь (MVF). Несмотря на широкое распространение информации об эффективности MVF, у специалистов, которые ранее применяли этот метод, но не добились положительных результатов при работе с пациентами, возникает много вопросов относительно специфики применения.

Цель. Оценить эффективность MVF для уменьшения выраженности фантомной боли в ампутированной конечности в условиях атипичного расположения фантома.

Материал и методы. В исследовании приняли участие 29 пациентов с фантомными болями в конечностях. Проведена оценка выраженности болевого синдрома и качества жизни.

Результаты. Установлено, что эффективность MVF зависит от таких важных факторов, как несоответствие расположения фантома на уровне ощущений и в отражении, длительность и выраженность болевого синдрома.

Выводы. Важный фактор успешных результатов применения MVF – это оценка исходной позиции фантома и способности изменять его расположение в пространстве на сенсорном уровне.

Уменьшение выраженности фантомных болей в отдаленном периоде может создать иллюзию того, что пациент адаптировался к проблеме.

Сроки и частоту курса MVF следует подбирать индивидуально, в зависимости от длительности, выраженности фантомных болей и утомляемости пациента.

Предполагается, что применение MVF в раннем реабилитационном периоде после ампутации предотвращает развитие фантомных болей, что требует дальнейших исследований в данном направлении.

Ключевые слова: фантомная конечность, ампутация, боль, реабилитация.

Для цитирования: Особенности применения зеркальной визуальной обратной связи у пациентов с фантомными болями в конечностях в условиях атипичного положения фантома / В. В. Бут-Гусаим, Л. А. Пирогова, А. С. Ярош, С. С. Василевский, Ю. Ч. Сирицына, А. С. Гальцев, С. Г. Гальцев, А. В. Копыцкий, В. Н. Чмель, Д. В. Степенкова // Журнал Гродненского государственного медицинского университета. 2022. Т. 20, № 3. С. 291-296. <https://doi.org/10.25298/2221-8785-2022-20-3-291-296>.

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