# Features of Mirror Visual Feedback Application for Patients With Phantom Limb Pain Under Conditions of Atypical Phantom Position

**Uladzimir But-Husaim** ( psychobvv@gmail.com )
Grodno State Medical University https://orcid.org/0000-0001-7843-2936

**Larysa Pirahova**
Grodno State Medical University: Grodnenskij gosudarstvennyj medicinskij universitet

**Anastasiya Yarosh**
Grodno State Medical University: Grodnenskij gosudarstvennyj medicinskij universitet

**Siarhey Vasilevsky**
Grodno State Medical University: Grodnenskij gosudarstvennyj medicinskij universitet

**Yuliya Sirytsyna**
Grodno State Medical University: Grodnenskij gosudarstvennyj medicinskij universitet

**Aleh Haltseu**
Project "MyoTriton"

**Siarhey Haltseu**
Project "MyoTriton"

**Andrei Kapytsky**
Grodno State Medical University: Grodnenskij gosudarstvennyj medicinskij universitet

**Vladimir Czmiel**
Independent Public Health Care Center in Miedzyrzec Podlaski

**Darya Stsepiankova**
Grodno Regional Clinical Hospital of Medical Rehabilitation

---

**Research Article**

**Keywords:** Phantom limb, amputation, pain, rehabilitation

**Posted Date:** October 28th, 2021

**DOI:** https://doi.org/10.21203/rs.3.rs-989863/v1



---

**Version of Record:** A version of this preprint was published at Journal of the Grodno State Medical University on July 18th, 2022. See the published version at https://doi.org/10.25298/2221-8785-2022-20-3-291-296.

# Abstract

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 features of the application.

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

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.

Conclusion

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 in patients in the long-term can create 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.


# 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 [1, 2]. One of these methods is Mirror Visual Feedback - MVF [2, 5, 9].

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 [9]. 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 [3, 4, 12, 7, 8, 13, 14, 9, 15, 16, 17, 18, 11]. 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 [3, 6, 8, 9, 19, 10].

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 [3, 20, 21, 4, 22, 7, 23, 24, 9, 19, 10, 25, 11].

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 [26]. 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 [5].

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 [1, 2, 7].

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.

# Materials And Methods

For the period from 2013 to 2020. 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). Also, 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).

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

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 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-a) or ankle and knee joints (for the lower extremities), and rotational movements were also performed (Fig. 2-b).

*Fig. 2-a Example of upper limb movements*

*Fig. 2-b 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. 3).

*Fig. 3 Analysis of the dynamics of the severity of phantom pain in the process of using MVF (Sign-test)*

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 ($p < 0.05$).

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. 4). 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.

*Fig. 4 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. 5).

*Fig. 5 Inconsistency of the ratio of reflection in the mirror with the real environment*

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.

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. 6).

*Fig. 6 Assessment of the severity of phantom pain and the duration of the symptom persistence in patients before the start of the MVF course (on the left - the ratio of the duration of the symptom and the*

*severity of pain; on the right - 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. 7).

*Fig. 7 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. 8).

*Fig. 8 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. 8).

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. 9).

*Fig. 9 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.

# Conclusion

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.

# Declarations

Funding - No funds, grants, or other support was received.

Conflicts of interest/Competing interests (include appropriate disclosures) - The authors declare that they have no conflict of interest relevant to the material presented in this paper.

Ethics approval - The study was approved by the ethical commission of the Grodno State Medical University.

Consent to participate - All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all patients for being included in the study. Additional informed consent was obtained from all patients for which identifying information is included in this article.

Consent for publication - All authors have given their consent to the publication.

Availability of data and material - all data and materials support their published claims and comply with field standards.

Authors' contributions

Conceptualization: But-Husaim U., Haltseu A., Haltseu S., Pirahova L., Yarosh A. Methodology: But-Husaim U., Pirahova L., Yarosh A.

Formal analysis and investigation: But-Husaim U., Pirahova L., Kopytsky A., Czmiel V., Stepiankova D., Vasilevsky S., Sirytsyna Y.

Writing - original draft preparation: But-Husaim U., Haltseu A., Haltseu S.

Writing - review and editing: But-Husaim U., Haltseu A., Haltseu S., Pirahova L., Yarosh A., Vasilevsky S., Sirytsyna Y.

# References

1. Maksimov RS., et al. Mirror therapy in early rehabilitation of stroke patients. Russian Journal of Pain.2016;50(2):133-134.

2. Nazarova MA., Piradov MA., Chernikova LA. Visual feedback - mirror therapy in neurorehabilitation. Annals of Clinical and Experimental Neurology.2012;6:36-41.

3. Butorina A., et al. Corrigendum to “The mirror illusion induces high gamma oscillations in the absence of movement”. Neuroimage.2015;107:54.

4. Hasanzadeh Kiabi F., et al. Mirror therapy as an alternative treatment for phantom limb pain: a short literature review. Korean J Pain.2013;26(3):309-311.

5. Sütbeyaz S., et al. Mirror therapy enhances lower-extremity motor recovery and motor functioning after stroke: a randomized controlled trial. Arch Phys Med Rehabil. 2007;88(5):555-559.

6. Yavuzer G., et al. Mirror therapy improves hand function in subacute stroke: a randomized controlled trial. Arch Phys Med Rehabil.2008;89(3):393-398.

7. Grünert-Plüss N., et al. Mirror Therapy in Hand Rehabilitation: A Review of the Literature, the St Gallen Protocol for Mirror Therapy and Evaluation of a Case Series of 52 Patients. The British Journal of Hand Therapy.2008;13(1):4-11.

8. Sumitani M., et al. Mirror visual feedback alleviates deafferentation pain, depending on qualitative aspects of the pain: a preliminary report. Rheumatology (Oxford).2008;47(7):1038-1043.

9. Ramachandran VS., Altschuler EL., Reflections on hand. Pain.2010;149(2):171-172.

10. Selles RW., Schreuders TAR., Stam HJ. Mirror therapy in patients with causalgia (complex regional pain syndrome type II) following peripheral nerve injury: two cases. J Rehabil Med.2008;40(4):312-314.

11. Michielsen ME. et al. The neuronal correlates of mirror therapy: an fMRI study on mirror induced visual illusions in patients with stroke. J. Neurol. Neurosurg. Psychiatry.2011.82(4):393-398.

12. Chan B.L. et al. Mirror therapy for phantom limb pain. N. Engl. J. Med.2007;357(21):2206-2207.

13. Diers M., et al. Mirrored, imagined and executed movements differentially activate sensorimotor cortex in amputees with and without phantom limb pain. Pain.2010;149(2):296-304.

14. Matthys K., et al. Mirror-induced visual illusion of hand movements: a functional magnetic resonance imaging study. Arch Phys Med Rehabil.2009;90(4):675-681.

15. Ramachandran VS., Altschuler EL. The use of visual feedback, in particular mirror visual feedback, in restoring brain function. Brain.2009;132(7):1693-1710.

16. Ramachandran VS., Brang D. Sensations evoked in patients with amputation from watching an individual whose corresponding intact limb is being touched. Arch. Neurol.2009;66(10):1281-1284.

17. Ramachandran VS. Phantoms in the Brain: Probing the Mysteries of the Human Mind. HarperCollins;1999.

18. Ramachandran VS., Rogers-Ramachandran D. Synaesthesia in phantom limbs induced with mirrors. Proc. Biol. Sci.1996;263(1369):377-386.

19. Rosén B., Lundborg G. Training with a mirror in rehabilitation of the hand. Scand J Plast Reconstr Surg Hand Surg.2005;39(2):104-108.

20. Ezendam D., Bongers RM., Jannink MJA. Systematic review of the effectiveness of mirror therapy in upper extremity function. Disabil Rehabil.2009;31(26):2135-2149.

21. Garry MI., Loftus A., Summers JJ. Mirror, mirror on the wall: viewing a mirror reflection of unilateral hand movements facilitates ipsilateral M1 excitability. Exp Brain Res.2005;163(1):118-122.

22. Cacchio A. et al. Mirror therapy for chronic complex regional pain syndrome type 1 and stroke. N. Engl. J. Med. 2009;361(6):634-636.

23. Matthys K. et al. Mirror-induced visual illusion of hand movements: a functional magnetic resonance imaging study. Arch Phys Med Rehabil. 2009;90(4):675-681.

24. Hozumi J. et al. Neurorehabilitation for Neuropathic Pain. Masui.2015;64(7):734-740.

25. Stevens JA., Stoykov MEP. Simulation of bilateral movement training through mirror reflection: a case report demonstrating an occupational therapy technique for hemiparesis. Top Stroke Rehabil.2004;11(1):59-66.

26. Seidel S., et al. Mirror therapy for phantom limb pain - a systematic review. Wien. Klin. Wochenschr.2009;121(13-14):440-444.

# Figures

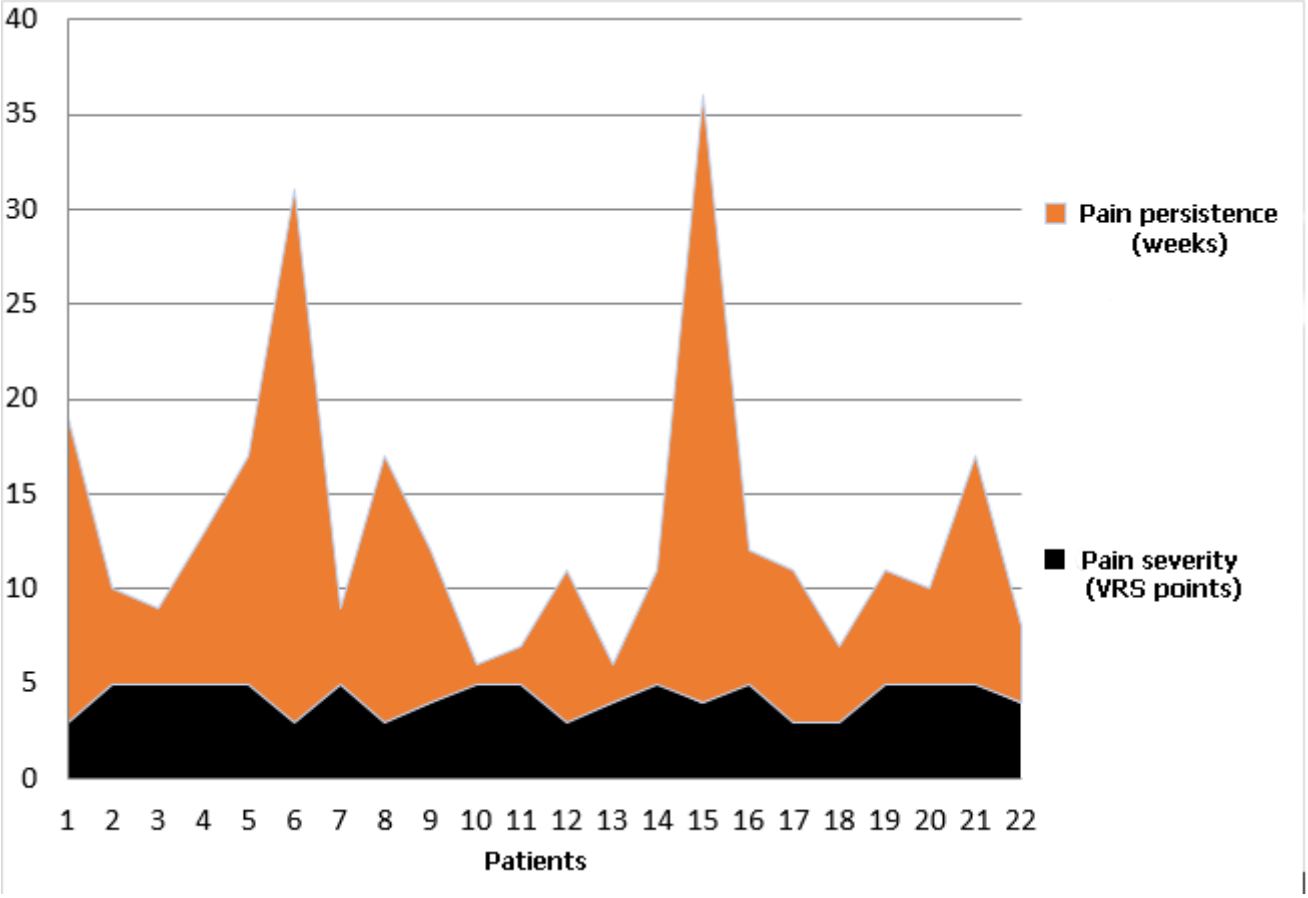
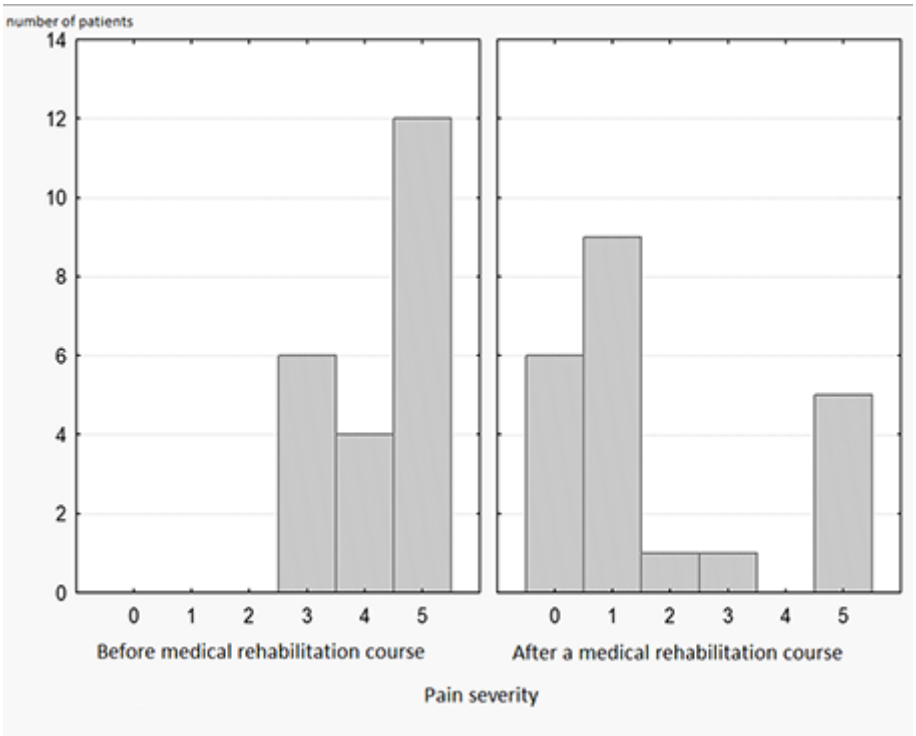



**Figure 1**

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

**Figure 2**

Fig. 2-a Example of upper limb movements Fig. 2-b An example of movements in the lower limb




## Figure 3

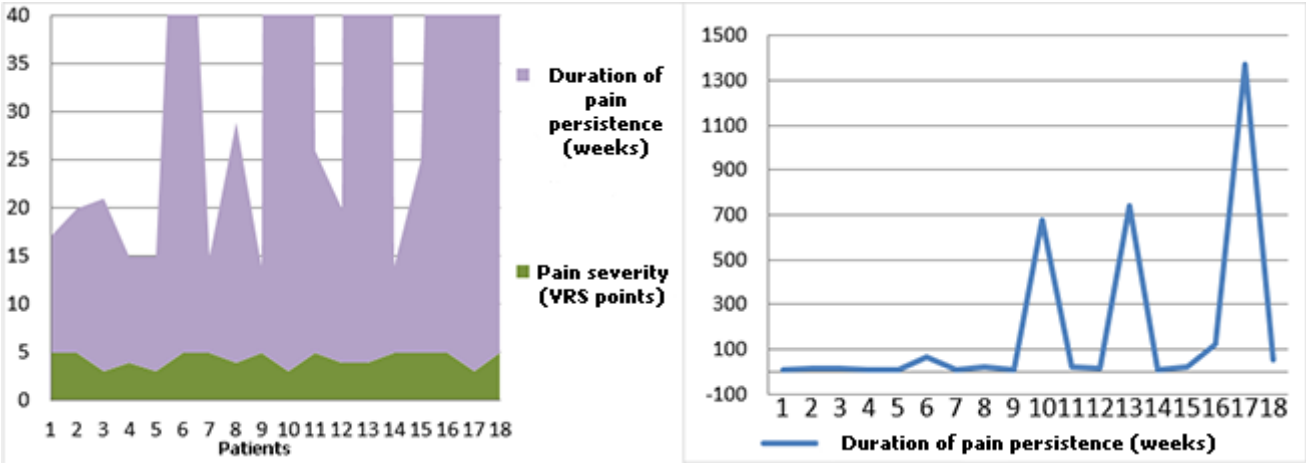
Analysis of the dynamics of the severity of phantom pain in the process of using MVF (Sign-test)

**Figure 4**

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)

## Figure 5

Inconsistency of the ratio of reflection in the mirror with the real environment




## Figure 6

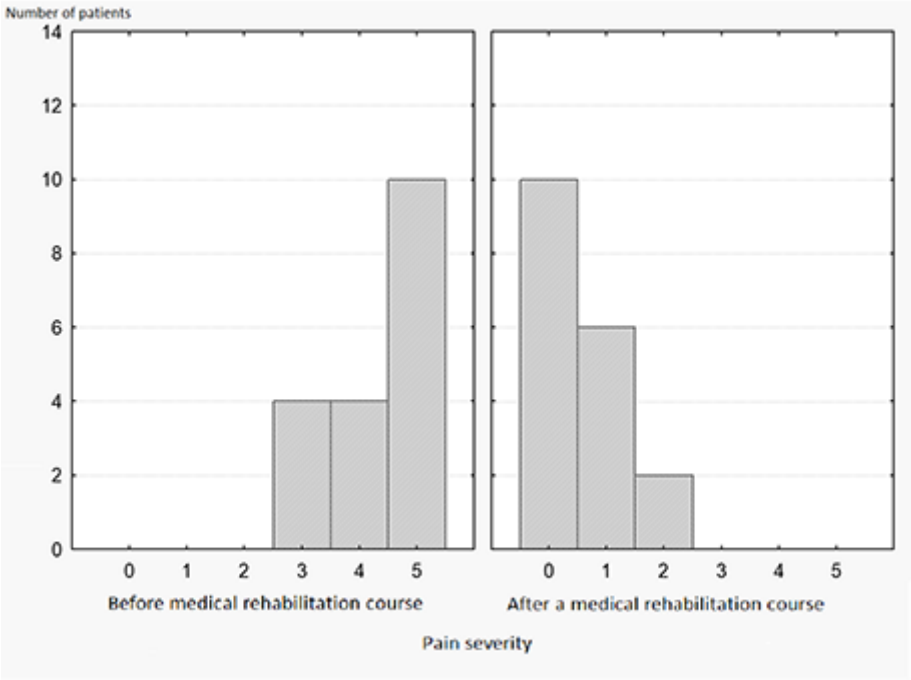
Assessment of the severity of phantom pain and the duration of the symptom persistence in patients before the start of the MVF course (on the left - the ratio of the duration of the symptom and the severity of pain; on the right - the duration of the persistence of pain, expressed in weeks)

**Figure 7**

Giving the intact limb an identical phantom position with muscle tension

**Figure 8**

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)




## Figure 9

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