fizjoterapia polska
nr 2/2016 (16)

Swoboda kontroli vs kontrola swobody – jak sprostać funkcji ręki w procesie fizjoterapii

Ease to Control vs Control of Ease- - How to Tackle the Functioning of Hand in the Process of Physiotherapy

Ewa Górna[1(A,B,C,D)], Zbigniew Śliwiński[2,3(D,E,F)], Marek Wiecheć[4(C,D,E)], Jan W. Raczkowski[5(E,F)]

[1]ProFizjo Warszawa, Polska/ProFizjo, Warsaw, Poland
[2]Instytut Fizjoterapii, Wydział Lekarski i Nauk o Zdrowiu UJK w Kielcach, Polska/Institute of Physiotherapy, Faculty of Medicine and Health Sciences UJK in Kielce, Poland
[3]Wydział Nauk o Zdrowiu Uniwersytetu Medycznego we Wrocławiu, Polska/Faculty of Health Sciences, Medical University in Wrocław, Poland
[4]Centrum Rehabilitacji MARKMED Ostrowiec Świętokrzyski, Polska/MARKMED Rehabilitation Center, Ostrowiec Świętokrzyski, Poland
[5]Uniwersytet Medyczny w Łodzi, Polska/Medical University in Łódź, Poland

Streszczenie:
Ręka ludzka stanowi wysoko wyspecjalizowany narząd o szerokim spektrum czynnościowym. Celem pracy jest przedstawienie oddziaływań fizjoterapeutycznych przeprowadzonych u pacjenta, leczonego operacyjnie z powodu rozległego urazu ręki, przedramienia i ramienia. W programie usprawniania uwzględniono wytyczne ICF, obawy oraz cele funkcjonalne zgłaszane przez pacjenta. Zastosowanie terapii pośredniej i zjawiska irradiacji typowych dla koncepcji PNF pozwoliło zminimalizować ryzyko podrażnienia przeszczepionych tkanek miękkich i skóry oraz uszkodzenia zespoleń wewnętrznych w obrębie nie zrośniętych okolic ręki i kciuka. W opracowaniu zamieszczono ryciny ilustrujące aplikowane stymulacje, omówiono również inne zastosowane oddziaływania terapeutyczne.

Słowa kluczowe:
rekonstrukcja ręki i przedramienia, fizjoterapia, PNF, irradiacja, funkcjonalność, terapia pośrednia

Abstract
A human hand is a highly specialized organ, with a wide range of functions. The aim of this report is to present physiotherapy treatment of the patient after surgery, which has resulted from an extensive injury to his hand, forearm and arm. During rehabilitation process, the ICF guidelines and the patient's concerns, as well as his expected functional goals, have been observed. Intermediate therapy and irradiation phenomena, standard of the PNF concept, have allowed to minimize the risk of irritation of the grafted soft tissue and skin, and of damage to the internal connections within the coadunate areas of the hand and thumb. The report contains illustrations showing the stimuli applied, it also discusses other therapeutic actions, which had been employed.

Key words:

Introduction

Individual personality and character, and the specifics of a person's regular activities, are expressed in the hands' appearance and dexterity. The human hand has a complex anatomical structure, it is equipped with a number of specialized, highly sensitive receptors, and it also has its extensive sensorimotor representation in the cortex. Often, it is being compared to a precision mechanism with a high degree of specialization and excellence, all of it precisely organized within a structure weighing less than 0.5 kilogram. Using this unique tool, we are able to execute tasks that originated in our brain and encompass a wide range of activities [1].

Sir Charles Bell, 19th-century anatomist, physiologist and neurologist wrote: "It is thanks to the hands, that a worker earns a living, parents caress their children, musician plays

sonatas, a blind man reads and a deaf and dumb man can talk". Among the 240 kinematic degrees of freedom, which characterize a human body, as many as 72 are positioned in the upper limbs, and 25 in each of the hands. Besides the flexibility of the agonist and antagonist muscles, there are also the additional, so-called dynamic, degrees of freedom – which make the hand one of the most perfect sections of our musculoskeletal system [2]. As a powerful prehensile tool, the hand makes it possible to perform the – requiring strength – objects' relocation tasks, constitutes an organ for the precise and multiplane manipulation, helps to perform the nonverbal communication tasks with gestures, as well as the perception-cognitive and the social-interaction functions; it may also be a tool for the artistic expression. According to N.A. Bernstein's theory of movement behavior, the motor performance is closely related to the proprioception (feed forward system) and the possibility of obtaining the feedback information about the result of the movement (feedback system). But with so many degrees of freedom, it is necessary to "align" (coordinate) movements of the individual segments, to launch the activity which would be spatially harmonious, aesthetic and functionally effective, and also having the correct timing (time consistency of the individual sequences of the motor task, assuring the movement efficiency) [3].

As the main obstacle for movement control, it is being considered the need to "freeze" (reduce) the excessive degrees of freedom in some joints, in order to increase the control of the movement in others. To this phenomenon refer stages of motor control – the universal diagnostic and therapeutic tool applied within the PNF (Proprioceptive Neuromuscular Facilitation) concept . Their structure reflects the progression in human development, which aims to automate voluntary movements while maintaining the postural and equilibrium strategies. This method allows, on the basis of the ontogenetic development standards, to determine the current stage of the sensorimotor control in a given patient, and to apply the optimal therapy procedures [4].

There are four stages of the sensorimotor control.

- Mobility – understood as the ability to achieve, in one sequence, a new starting position, or the possibility to obtain correction of posture, which requires the proper joint mobility and muscle activity in the concentric contraction.
- Stability – the ability to maintain the corrected posture, based on the isometric muscle activity of the antagonist, synergistic units.
- Mobility with stability, also known as coordination – is being defined as the capacity to simultaneously control the static element (posture), using the isometric or auxotonic muscle contractions, and the mobile element, being the lever supported by the stable element. The resulting multitasking imposes on the system the separation of the control functions – the mobile component is being monitored cognitively, while the static one by the subcortical functions (automatically).
- Dexterity – regarded as complex activities carried out with the unpredictable impact of environment (unstable supporting plane, time factor, use of tools and equipment), with the cortex control directed to other tasks, such as counting, spelling, se-

quential movement to the developmentally more difficult starting position, movement in relation to the ground – interpreted in the wide sense as locomotion.
Our patient has been subjected to stimulation according to the main principles and techniques of the PNF concept, and has learned to achieve a new starting position (mobility), to build up stabilization control in the position (stability), perform voluntary movements while maintaining correction (coordination), and has been able to continue a task despite the changing environment conditions (dexterity), e.g. spatial or time limits [5].

Case Study

To our facility came 44 years old patient. Two months had passed since the extensive mechanical trauma to his left hand, and the numerous injuries within his forearm and arm areas, had occurred. The man had undergone a surgery, which took place three days after the accident.
During surgery the following procedures had been done:
• internal fixation of the radius, ulna and humerus with a metal plate, and of the thumb with the use of wire
• reconstruction of soft tissues (radial nerve, forearm and thenar muscles) and of vascular bed
• skin graft in the area of flexor muscles on the inner surface of the forearm

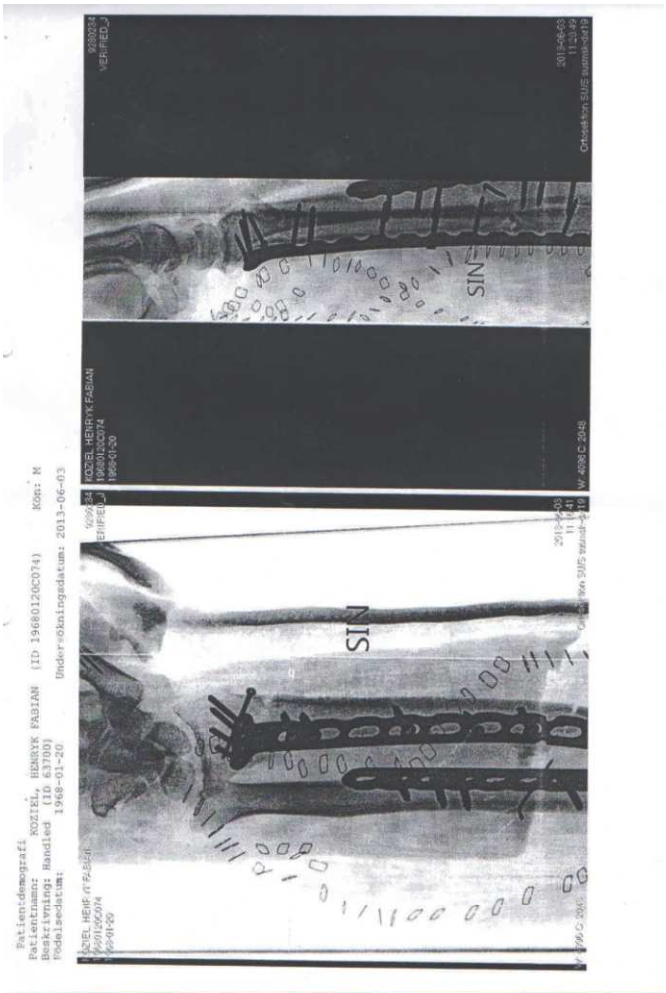

Fig. 1. Postoperative radiographs of the forearm

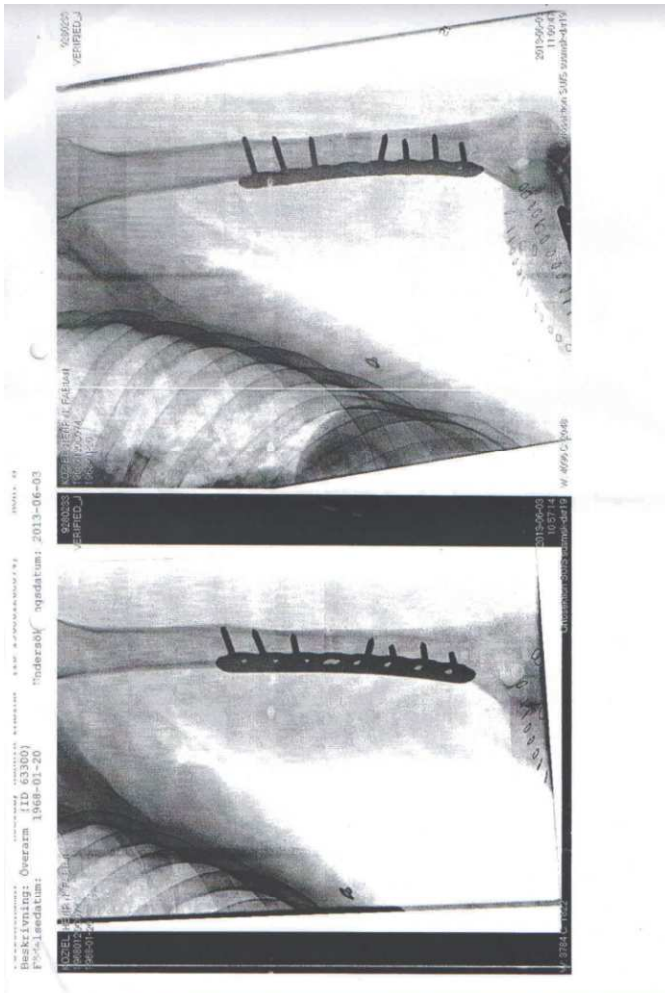

Fig. 2. Postoperative radiographs of the arm

Due to the type of the injuries – teared off lacerations and crushed areas – the prognosis has not been optimistic. The patient complained on strong pain sensations throughout the limb, hyperesthesia in the areas of the forearm and wrist joint, numbness and intense swelling in the dorsal areas of hand and fingers, extensive rigid scars, dry and dark red colored skin [8, 10, 11, 13].

Fig. 3. Patient's body position in the sagittal plane

Fig. 4. Patient's body position in the coronal plane

Visual and Physical Examination

Both, in the seated and standing position, an asymmetry of the patient's body has been observed – hypertonic sternocleidomastoid muscle, lowered shoulder line and lateral shortening of the torso on the left side, protraction of the left shoulder joint, high degree of atrophy of the upper extremity muscles, getting worse in the distal direction.

Fig. 5. Hand and forearm orthosis

Fig. 6. Hand and thumb with the stabilization wire

The patient had been using a dynamic hand and forearm orthosis, prepared in the studio of professor M. Pieniążek. The orthosis was supposed to counter deprivation of the joints mobility. The patient had had the orthosis applied all day long, except for hygienic and psychotherapy procedures.
Assessment of the patient's movement ability focused only on the active movements, due to the incomplete bone adhesion process and the lack of mineralization within the arm and forearm bones, and the total lack of bone adhesion in the thumb area. During the physiotherapy examination there have been established:
• limited active mobility in the shoulder joint complex in adduction to 90°, abduction to 30°, glenohumeral joint rhythm disorder;
• range of the adduction in the elbow joint – 40°, no pronation movements nor forearm supination;
• lack of mobility in the wrist joint, assessment of the muscle strength not possible;
• scarce movements of the interphalangeal joints of the fingers 2-4, lack of mobility in the thumb and the metacarpophalangeal joints.
As the main functional problems, the patient had indicated the complete disability of his left hand, swelling and pain, which all made him dependent on others in performing the basic self-servicing tasks, as well as the limitation of joints mobility, atrophy and significant loss of muscle strength, lack of both, exteroceptive and deep sensation, cardiovascular and thermal discomfort.
From a physiotherapist point of view, the ranking of the therapeutic challenges in this patient had been as follows:
• pain,
• deficit of sensation,
• disorder of the body symmetrical position (deviation from median line) and the posture control,
• atrophy of the shoulder muscles, no innervation in the forearm and hand muscles,
• impossibility of the direct stimulation (extensive skin surface wounds, no bone adhesion, effects of the circulatory disorders, dryness and lack of flexibility in the grafted skin fragments, resulting in their high susceptibility to injury).
Evaluation of the functional status of the patient, considering his body structures and functions, and his activity and participation (ICF), has helped to identify the three key objectives for the therapy:
• postural reeducation (exercises for torso muscle bands, shoulder girdle stabilization, repositioning of rib cage),
• facilitation of the left hand activity (intermediate therapy using the irradiation phenomenon, within the closed chains system, restoration of the functional linearity in the wrist joint),
• taking into account the stages of motor control in building up the motility of the hand.

Early rehabilitation phase

The patient did not tolerate any external stimuli within the injured hand and forearm, did not attempt to activate the muscles in this area on his own, the grafted skin fragments he treated as

a foreign tissue and did not identify himself with it [12]. All of the above prohibited the use of any direct stimuli on the surgically treated hand. The method of choice became the PNF concept, utilizing the irradiation phenomenon for the process of rehabilitation, which involves delivery of the neuromuscular stimulation to the injured areas, through the stimulation applied to the areas that are strong and free of pain. This is aimed to achieve the synergistic activity within the dysfunctional or even immobilized hand, often in closed kinematic chains systems, and is being called the intermediate therapy [6].

Among the advantages of using the irradiation method, there are:

• high level of safety and emotional comfort for the patient,

Fig. 7. A combination of isotonic contractions in a side-lying position

Fig. 8. Reciprocal stabilization of the torso in a side-lying position

Fig. 9. Rotation of the lower torso – a combination of isotonic contractions in the direction of flexion

Fig. 10. Rotation of the lower torso – a combination of isotonic contractions in the direction of extension

• possibility to maintain the required level of intensity of the stimuli,
• facilitating the reinnervation of the stimulated area,
• preventing the effects of the direct fatigue.
The therapy had been applied in the sitting, supine and side-lying positions, as well as in standing position.
The irradiation stimuli had been drawn from the lower limbs, pelvis, torso and from the upper limb. The applied treatment included stabilization techniques, combination of isotonic contractions and dynamic continuous reciprocity, and stimulation of breathing.
There have been archived the following results of the treatment:
• full, painless active mobility in the shoulder and elbow joints in adduction, abduction and supination. Pronation was possible within the range of 60°, at the final stage of the movement the patient reported a stiff limitation, caused possibly by the metal joining the fractured bone;
• within the wrist joint there has been achieved painless, passive palmar flexion within the range of 70°, active – 50°, with the muscle strength rated at 3 in Lovett's scale. The passive dorsiflexion movement has reached 20°, actively the patient has been able to return from the palmar flexion to the intermediate position, with the muscle strength of 2. There has also been achieved a slight active abduction movement towards the elbow and radius;
• functioning of the fingers developed within the full physiological range, with the grip strength of 4/5 in Lovett's scale, in the metacarpophalangeal joints the patient has gained mobility range of 60° and the muscle strength of ¾;
• despite the lack of the complete bone adhesion, and the sustained deficits in the thumb mobility, the patient has become able to perform the reciprocal motion with the possibility of the tweezers-like grip.
Our patient has highly evaluated the therapy results, indicating the clear improvement of his quality of life, brought about by the lack of pain, reduction of swelling and regaining of the faculty to feel, which in consequence gave him independence in performing his daily hygienic tasks and the simple manual activities, requiring a grip function. Our observations are confirmed by the literature on the subject [8.9].

Functional Improvement Phase

The progressing bone adhesion, improved functional and circulatory capacity and the gradual indurating of the limb to external stimuli (touch, pressure, thermal stimuli), made it possible to widen the scope of the applied procedures with the physical and manual therapy [14, 15]. The following techniques have been applied: Kinesiology Taping, scar mobilization, polarized light, red 630Nm laser on the scars and the skin graft areas (for the normalization and organization of collagen fibers in the scars and the graft), whirlpool bath, magnetic field, electrical stimulation of the radial nerve (despite the internal stabilization with metal plates – the implants made of titanium, electrically neutral, made it possible to perform the treatment, even though the electrodes had been placed on the surface), preventive protection and regeneration of the radial nerve with a glove and a thermal sleeve (to maintain the constant temperature, without overheating,

and focus the patient's attention on his hand), procedures against the swelling – lymphatic drainage massage and prophylaxis of the lymph stagnation (high placement of the extremity, muscle pump mobilization, Kinesiology Taping for lymphatic drainage). The kinesiotherapy has been continued, using the PNF concept, and in addition to the intermediate therapy – activities with the progressive axial loads and the techniques of reciprocal and rhythmical stabilization, combination of isotonic contractions, restoration, dynamic continuous reciprocity. We have applied the following main facilitation principles: manual resistance, irradiation, change of the normal movement sequence, visual contact and approximation.

Fig. 11. Sternum - reciprocal stabilization technique, combination of isotonic contractions

Fig. 12. Front depression of the scapula - combination of isotonic contractions technique

Fig. 13. Sternum breathing in sitting position

Fig. 14. Rhythmic stabilization in the arm movement patterns, flexion/abduction/external rotation – extension/adduction/internal rotation, in sitting position

Fig. 15. Change of the normal movement sequence – stressing the external rotation movement of the left arm

Fig. 16. Activities in position of the body supported on forearms (push-up)

Fig. 17. Possible hand manipulations in the final stage of rehabilitation

Fig. 18. Visual motor integration in daily activities

Summary

The human hand is often subject to injuries or distortions due to diseases or congenital disorders. Its orthopedic dysfunctions generally result in the secondary stiffness and limitation of movements of the other upper limb joints. From the mechanical point of view, in addition to the traumatic damages, there is also observed substantial instability or overstrain within the joints of shoulder girdle, neck and torso. The correct mobility in the shoulder and elbow jo-

ints, including the internal and external rotation of the forearm, determines the optimal functionality of a hand. It does seem therefore rational, to include into the physiotherapy process the special stimuli of the hand and fingers joints, but also to provide the optimal conditions for their functioning, through the postural reeducation of a patient, stabilization exercises for the pectoral arch with the repositioning of the rib cage and recreation of the functional linearity in the wrist joint, while stressing the hand specific high level of the sensory perception.

Adres do korespondencji / Corresponding author

Zbigniew Śliwiński

59-900 Zgorzelec, ul. Św. Jana 26E
e-mail: dr_sliwinski@post.pl

Piśmiennictwo/ References

1. American Society for Surgery of the Hand. The Hand – Examination and Diagnosis. PZWL Warszawa 1986
2. Petryński W. Zarys teorii budowy ruchów Nikołaja Aleksandrowicza Bernsztejna. materiały pomocnicze GWSH Katowice 2007
3. Hochschield J. Strukturen und Funktionen begreifen. Funktionelle Anatomie – therapierelevante Details. tom 1, Georg Thieme Verlag. Stuttgart 2002
4. Górna E. Koncepcja Proprioceptive Neuromuscular Facilitatiion. W Wielka Fizjoterapia. t.3 red. Śliwiński Z,, Sieroń A. Elsevier Urban & Partner, Wrocław 2014. 107-123
5. Pruszyńska M., Górna E., Leszczyńska A., Przedborska A. Zastosowanie metod neurofizjologicznych u pacjentów ortopedycznych. Kwartalnik Ortopedyczny 2/2011. www.kwartalnikortopedyczny.pl
6. Mańka J., Milewska M. Otwarte i zamknięte łańcuchy kinematyczne. Acta Clinica 2001, 1(3) 231-237
7. Doleżał S. A. Zamknięte uszkodzenie aparatu więzadłowego i ścięgien ręki. Kwartalnik Ortopedyczny 2002, 3, 147
8. Kasashima T., Kato H., Minami A. Treatment of flexor pollicis longus tendon lacerationis. W: 6th Congress of the International Fofederation of Societes for Surgery of the Hand. Helsinki, 237
9. Manikowski W., Jaruga M., Dolata M., Ilów M., Koprowska M. Leczenie usprawniające chorych po plastyce ścięgien zginaczy rąk w ich zastarzałych uszkodzeniach. Chirurgia Narządów Ruchu i Ortopedia Polska 1997 supl. 181
10. Sikora T., Kozdryk J., Bieniecki M., Lorczyński A., Jabłońska-Brudło J. Retrospektywna analiza wyników leczenia chirurgicznego uszkodzeń ścięgien zginaczy. Ann. Acad. Med. Gedan. 2006, 36, 167
11. Chrapusta A. Krakowskie procedury transplantacyjne. Chirurgia Plastyczna i Oparzenia 2015, 3, 2, 39-50
12. Kowal K. Kryzys tożsamości w doświadczaniu ciała zrekonstruowanego przeszczepem kończyny górnej. Hygeia Public Health 2012, 47(4), 477-483, www.h-ph.pl
13. Deja W. Wczesne i odległe następstwa obrażeń naczyń obwodowych u chorych po zabiegach rekonstrukcyjnych. Ann. Acad. Med. Gedan. 2005, 35, 35-52
14. Wiecheć M., Bauer A, Przewodnik metodyczny po wybranych zabiegach fizykalnych. wyd. II, Markmed Rehabilitacja, Wrocław 2012
15. Śliwiński Z., Krajczy M. Plastrowanie dynamiczne. Markmed Rehabilitacja, Ostrowiec Świętokrzyski 2014