# HOW TO TREAT

OTWorld Edition 2024

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# Contents




# Cross-Border Exchange for the Future Provision of Orthopaedic Aids

In recent decades, new fitting concepts, new materials and new manufacturing techniques have been the dominant topics at OTWorld – the world congress and leading global trade fair. The aim is to continue to improve the worldwide care of people who rely on orthopaedic aids such as prostheses, orthoses, wheelchairs, bandages and compression supplies. After all, there are no such things as off-the-shelf orthopaedic aids. Every single advance and all progress made in terms of knowledge and experience means greater participation for a user and with it, even better quality of life. This is why orthopaedic technicians, orthopaedic footwear professionals, rehabilitation technicians, retailers for healthcare supplies and medical retailers, engineers, doctors and physiotherapists from all over the world come together in Leipzig every two years. We all know that together, we can only advance the provision of orthopaedic aids through interdisciplinary and international dialogue.

The long-standing and close partnership between the International Society for Prosthetics and Orthotics (ISPO) and the German Association of Orthopaedic Technology (BIV-OT) ensures that this exchange of knowledge and experience is successful across all borders, disciplines and professions. Last but not least, our joint project, the annual "HowToTreat" edition, contributes to the international transfer of knowledge.

For the past two years, we have seen a kind of "back to the future" development in Europe: the care of war casualties, which was a major concern in our discipline after the two world wars in the first half of the 20th century, is once again at the top of the agenda. None of us knows the exact numbers of seriously injured people in the war zones of the Ukraine or the Middle East. However, we do know of the reports from colleagues who are providing care on the ground in the most unfavourable of conditions, or information concerning the few war casualties who are being cared for in third countries.

We can only hope that, as in the case of the so-called Franco-German enmity, this will eventually lead to peaceful coexistence. With this in mind, we are particularly pleased to have France as the partner country of OTWorld 2024. France is hosting the Olympic and Paralympic Games this year. Accordingly, we are expecting a large number of athletes and orthopaedic technicians in Leipzig. And of course, the topic of sports orthopaedics will play a role in this year's "HowToTreat" edition. However, we are just as excited to hear what our colleagues from France have to say about their treatment standards, innovations and the market for orthopaedic aids in the heart of Europe.

Dear readers, between the 14th and the 17th May 2024 in Leipzig, our aim is nothing less than to talk to you about the future provision of orthopaedic aids in a peaceful atmosphere characterised by mutual respect. We look forward to continuing our dialogue with you!

Yours,

Alf Reuter, President of
German Association of
Orthopaedic Technology

Photo: International Society of Prosthetics and Orthotics

# The Input of an Orthopaedic Technician at the Early Stages of Rehabilitation is Crucial

The role of an orthopaedic technician (OT) is a crucial one in the rehabilitation and ongoing support of people with mobility impairments and functional restrictions. The role covers many aspects of the needs of people including their posture, stance, mobility, and activities of daily living, all crucial to create the right environment for an active independent and fulfilling quality-of-life.

As a full-time wheelchair user since 1982 following a high-level spinal-cord injury, my interaction with my OT during the acute and latter phases of my rehabilitation were crucial. From the very first days my OT created orthotic night splints which, with no hand function, kept my hands in good form to enable them to be useful to me in my later rehabilitation. After getting up into a wheelchair I needed 'cock up' wrist splints to enhance my independence. The interaction between my occupational therapist and my OT were crucial on my journey to leaving the rehabilitation setting and going on to live in society. However, the interaction did not stop there as once I get out into the community, to study and then to work, I needed different input from my OT. As I gained more strength and ability to perform different functions, such as typing with splints, shaving, cleaning my teeth and importantly eating independently, my OT was played a vital part in adapting my splints for those purposes. A relationship that continues today, 40 years later.

Now, as President of the International Society for Prosthetics and Orthotics (ISPO), I know how close the direct link between an organisation like ISPO and the profession of orthopaedic technology really is. It is therefore very important that the two organisations, ISPO and OTWorld are direct collaborators. ISPO is very proud to be a partner/collaborator with OTWorld.

One of the themes of this year's OTWorld is that of 'Ensuring Appropriate Rehabilitation in Emergency Situations' and several experienced experts who are also ISPO members have been asked to present their thoughts on the importance of this. Many people might consider OT as a luxury in emergency situations, however the input of an orthopaedic technician at the early stages of rehabilitation, whether it be an emergency response situation or not, is crucial. I know for a fact that my hands would not be as well shaped and remain functional (even though they are paralysed) had I not had early input from an orthopaedic technician.

With the upcoming Paralympics in Paris this year, once again the role of an OT is important to high-level athletes. Certainly, in wheeled sport such as wheelchair basketball, racing and tennis, posture and balance is everything. Many high level, even professional, athletes will have benefited from the input of an orthopaedic technician. Something many people don't even realise.

While the Paralympics is a key global showcase for people with disabilities every four years, the key to a successful Paralympics is what happens afterwards in the host country, but also all the other countries that took part. Unless there is an ongoing 'legacy programme' that is well funded and continued for years after the games, the Paralympics could simply become a showcase for elite athletes. It is in the legacy programmes that we get grassroots sports going and more people involved, many of whom will need an orthopaedic technician to adapt seating or provide support to weaker parts of the body or help them perform to a higher level.

I have outlined a few of the areas where the link between OT and P&O are crucial and fundamental and, as President of ISPO for the biennium 2023-2025, I would like to welcome you to join us at the ISPO congress in Stockholm in June 2025.

Yours,

David Constantine MBE,
President of International Society
for Prosthetics and Orthotics

Photo: David Constantine

W. M. Strobl

# Senso Orthotics with Compression and Electrostimulation in Cerebral Movement Disorders – What Do We Know about Effectiveness?

**Sensory deficits in children and adults with cerebral movement disorders are underestimated. Exteroceptive and proprioceptive stimuli from the periphery cannot be processed sufficiently centrally to ensure adequate control of posture and movement. The consequences are progressive secondary effects of non-use, pain, and musculoskeletal changes.**

**Stimulation of the mechanoreceptors through compression and electrostimulation allows non-invasive activation of the sensorimotor system and a subjectively and objectively measurable improvement in quality of life. Numerous observational studies and experiences report positive effects. Senso orthoses with compression and/or electrostimulation can reduce pain, regulate tone, and improve the patient's physiologically and psychologically important posture and movement. However, as in many other cases of multimodal conservative treatment measures, the scientific evidence is not yet sufficient for a conclusive statement for most senso orthoses. For all senso orthoses with compression and/or electrical stimulation, exact diagnostics and testing by an experienced team are essential to finding the best possible therapy option.**

**Keywords:** Senso orthoses, Compression Suits, Full Body Compression Suits, Electrostimulation, Electrostimulation Suits, Cerebral Movement Disorder

## Introduction

Children and adults with chronic disorders of brain function, such as after brain development disorders, after an ischaemic or hemorrhagic stroke, after traumatic brain injury or encephalitis, or in multiple sclerosis, live with varying degrees of impairment of their everyday activities depending on the location and extent of the damage. Grasping, speech, vision, hearing, sitting, standing, and walking functions, as well as cognitive, emotional, and psychosocial abilities, can be affected.

Posture, standing, and walking are complex sensorimotor functions. If the performance of the central nervous system is impaired, abnormalities in posture, speech, gripping ability, and gait can be observed. However, this motor symptomatology is based on disorders of motor AND sensory functions, with particular attention being focused on the latter.

In healthy people, exteroceptive stimuli from the environment are received and transmitted via pressure and temperature receptors and sensors in the skin and subcutaneous tissue and the stretch receptors in connective tissue, fascia, and muscles. They are linked to proprioceptive stimuli of the body's position via position receptors in the organs of balance, fascia, muscles, and joint capsules and are processed for perception based on associations and experiences. Now we recognize – primarily unconsciously – the starting position of our body. This is the prerequisite for the tonic postural muscles to control the stability of the head, trunk, and leg axes under the conditions of gravity and for movements to be planned and controlled by the phasic drive muscles.

In people with cerebral movement disorders, the processing and coordination of this information from the periphery is impaired. The information from the sensors is not processed or is processed incorrectly and is not sufficiently available for the planning and control of motor functions (Fig. 1). The lack of postural and movement control leads to an additional secondary deterioration in sensorimotor function. Musculoskeletal changes are caused on the one hand by „non-use" and on the other by misalignments of body parts that cannot be perceived as incorrect positions.

These are initially reversible but progressively painful and, depending on their severity, develop into irreversible deformities of the supporting and locomotor organs (Fig. 2).

In recent years, three-dimensional movement analysis studies have revealed autoregulatory mechanisms of the skeletal musculature that attempt to stabilize the body under the conditions of gravity through muscle overactivity in cerebral movement disorders. The weakness of the tonic postural muscles appears to be compensated for by an overactivity of the phasic movement muscles of the extremities, which can be observed as „spasticity" [1].

On the other hand, in less active, non-ambulatory patients, the inac-

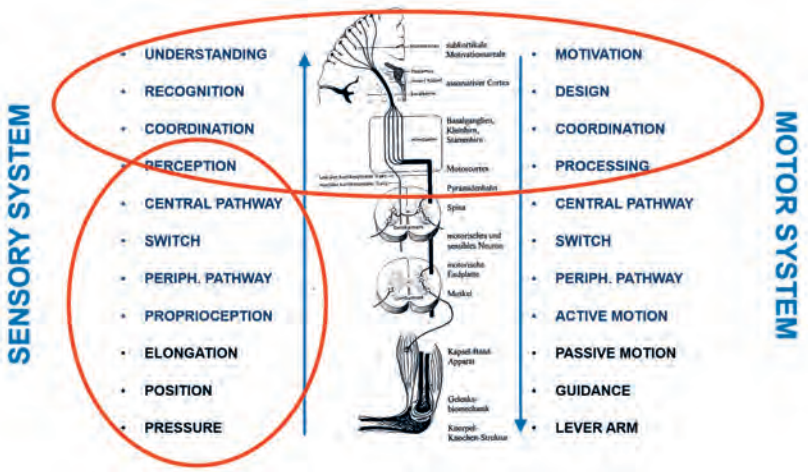


*Fig. 1 The cerebral processing disorder of the sensory input is significantly involved in the development of a movement disorder.*

tivity of the skeletal musculature, the lack of muscle mass, and the lack of training lead to a lack of anti-inflammatory substances. The resulting uninhibited neuroinflammation generated when nociceptive nerve fibers are stimulated switches on the pain amplifier and weakens the body's pain defenses [2]. This is suspected to be one of the causes of the development of underestimated chronic pain in people with severe cerebral movement disorders.

In children, the dimension of maturation and development must also be taken into account. Achieving standing and walking for the first time is a milestone in a child's development and is directly linked to the development of the psyche and self-confidence.

Severe neuromotor disorders lead to a lack of maturation of the sensorimotor system and, in the absence of sufficient training, subsequently to disorders of the locomotor system and other organ functions. Studies show that all children with cerebral palsy, regardless of age, live with musculoskeletal pain, which is all the more severe the less mobile the children are [3, 4].

This study aims to compare the practical experience with various afferent-stimulating „sensory orthoses" in children and adults with cerebral movement disorders with the previously published literature and to provide the treatment team with an overview of the current state of knowledge. The search criteria for the systematic literature search on the mode of action, clinical experience, indications, and outcome of the various types of orthoses in the Pubmed database were the terms cerebral disorders, stroke, cerebral palsy and sensory orthoses, sensory input orthoses, pressure input orthoses, electrostimulation orthoses, compression suits, electrostimulation suits.

## Development of senso orthoses to improve posture and movement control

The aim of all assistive devices for people with cerebral movement disorders and neuromuscular diseases is to compensate for sensorimotor dysfunction to enable physiological activity and avoid pain and secondary damage to the body. When developing effective orthoses, it is therefore obvious to make the best possible use of residual sensory functions, to stimulate the functional peripheral exteroceptive and proprioceptive receptors and thus to train unconscious perception through mechanisms of neuroplasticity to create the conditions for an adequate response of the motor system, tonic holding and phasic movement activity.

Senso-orthoses would thus be able to positively influence the „non-use" of neuronal afferents on the one hand and – through their additional mechanical stabilizing properties – the development of malpositions of body parts, pain, and musculoskeletal changes on the other.

The aims of senso orthotics can be summarised as follows:

1) Elimination of pain
2) Improving the strength of the tonic „anti-gravity muscles" with the strengthening of head, trunk, and posture control and easier activation of the upper extremities
3) Improvement of sensory function and perception with influence on muscle tone and inhibition of spastic muscle overactivity
4) Improvement of speech motor skills and thus communication and food intake

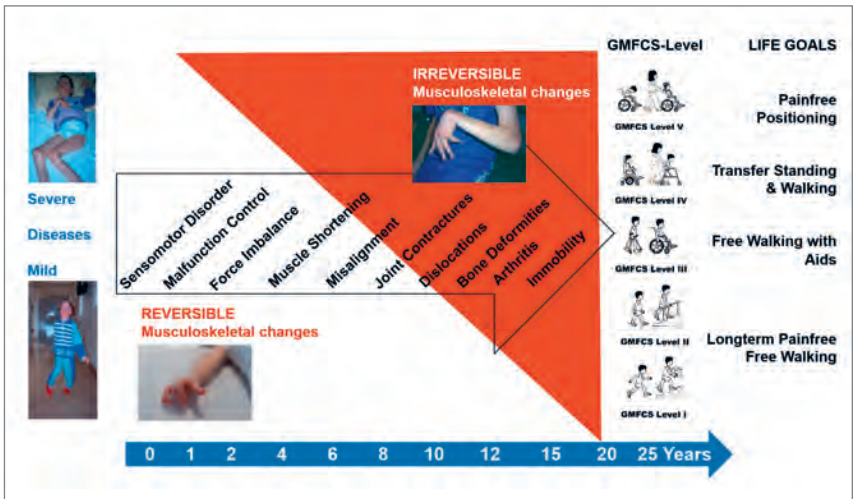


*Fig. 2 The earlier the treatment of progressive musculoskeletal changes with pathological sensorimotor function, the more effective it is.*

5) Increasing the range of movement of muscles and joints with prevention of secondary damage by maintaining the extensibility of the muscles and thus avoiding contractures and consecutive bony deformities as well as avoiding frequently underestimated musculoskeletal pain
6) Normalisation of the lever arms to enable strength training of the muscles
7) Influencing cartilage growth and joint development
8) Loading of the lower extremities and spine to prevent inactive osteoporosis
9) Stimulation of the growth plates at a growing age
10) by improving muscle strength and mobility, better cardiopulmonary performance, and improved function of internal organs and metabolism
11) normalization of serotonin metabolism and improvement of cerebral performance through verticalisation
12) Reduction of psychological problems by increasing self-confidence
13) Achievement of social participation

The sensory orthoses and sensory aids currently developed and clinically available to children and adults with cerebral movement disorders can be divided into five groups with different approaches to their mode of action:

– Heat
– Compression (and verticalisation)
– Locomotion [5]
– Vibration
– Electrical stimulation

Aids utilize central residual sensory functions through these specific physical mechanisms and the associated exteroceptive and proprioceptive stimulation, train unconscious perception through mechanisms of neuroplasticity, and thus create the conditions for physiological motor skills. In five different ways, these can help prevent the „non-use“ of neuronal afferents on the one hand and the development of malpositions, pain, and musculoskeletal changes on the other.

## How do senso orthoses work through compression?

Unlike compression therapy to improve the flow properties of the blood and lymph vessels, the pressure does not act on the connective tissue to increase the tone of the vessel walls, but on the neural mechanoreceptors, which are the primary pressure and stretch sensors responsible for exteroception and proprioception. Proprio- and exteroceptive input enables training of the afferent system with improved depth perception and thus activation and strengthening of the tonic postural muscles.


***Fig. 3*** *Elastic textile compression orthoses stimulate the mechanoreceptors and improve posture and movement control through the application of sensory stimuli.*

It is known from numerous space research studies that proprioceptive and tactile stimuli must be applied repeatedly over longer periods in the absence of gravity to maintain postural control and allow astronauts or cosmonauts to adapt more quickly to gravity after returning to Earth [6]. This basic principle of permanent sensory stimulus application takes up the complex method of „proprioceptive correction“ and enables the treatment of people with severe brain damage and movement disorders in the context of neurorehabilitation [7].

## Development of compression orthoses for cerebral movement disorders

Kozijavkin was the first to use a movable corrective suit from space travel for the treatment of children with cerebral movement disorders in the 1990s at the Truskavets International Rehabilitation Clinic in Ukraine. His observations on site and a field report published in the Lancet showed an improvement in posture and movement and a reduction in spasticity as part of multimodal intensive rehabilitation [8]. A similarly constructed compression orthosis leads to an improvement in gait in the context of multimodal intensive rehabilitation according to Adeli [9].

The corrective suits were further developed as elastic, skin-tight whole-body compression orthoses for the trunk or individual body parts, such as the pelvic girdle [10]. A study on the trunk orthosis „Spio“ („Stabilising Pressure Input Orthosis“) showed improvements in kyphotic malpositions in combination with multimodal outpatient or inpatient treatment, but not in scoliosis and hip dislocations [11]. The compression orthoses available on the market, such as the „Dynamic GPS Soft Orthosis“, „Flexa Barbieri SLR Orthosis“ and „Protheseus TLSO Vest“ (Fig. 3), have a similar structure.

Quality criteria make it easier to assess the effectiveness and significance of the overall treatment concept: compression trunk orthoses should enable subjectively and objectively measurable improvements in trunk stability and hand function in conjunction


***Fig. 4*** *Dynamic trunk orthoses utilize the principle of sensory stimulation through compression and heat in combination with individually required mechanical stability to strengthen the trunk muscles.*

with conventional therapy and everyday activities. In practice, orthopaedic improvement is very often necessary with additional elastic reins and partial stiffening.

There is evidence for the improvement of active sitting function, improvement of hand motor skills, and head control by stabilizing the trunk. The prerequisite is the absence of more severe respiratory or skin problems. The indication is given for flexible spinal instability without structural deformities, such as kyphosis or scoliosis, with sufficient residual trunk muscle function for active straightening. Pronounced trunk muscle weakness and structural deformities are contraindicated. A systematic review from 2021 included 12 studies on dynamic compression orthoses (such as Therasuit, Theratog, Adeli, and others). In children with cerebral palsy, significant changes in gait speed, cadence, stride length, and symmetry were found in conjunction with training programs, so the authors recommend 18-60 sessions to achieve optimal results [12].

The basic principle of „dynamic stability“ in neuro-orthotic treatment was already described in the 1960-1970s by Adriano Ferrari, a neuro-rehabilitation physician and student of Milani Comparetti, who stated that the best orthosis enables sensorimotor learning through neuronal plasticity by allowing mobility of all joints [13].

Dynamic orthotic treatment therefore also utilises these mechanisms. Compression is caused by the semi-elastic, close-fitting design and strain on the mechanoreceptors during verticalisation. Thanks to largely released joints, tonic, and phasic muscles can be maximally activated and strengthened by securing physiological points of origin and attachment as well as lever arms despite central paresis.

Dynamic trunk orthoses (semi-rigid to rigid trunk support orthoses, plastic support corsets, Chêneau-Münster corsets) are more stable than purely textile compression orthoses. Still, due to their dynamic stability, they also utilize the treatment principle of exteroceptive and proprioceptive stimulation of the mechanoreceptors in addition to their mechanical support function (Fig. 4). There is evidence in the literature for the achievement of sitting function, improvement of hand motor skills and head control through dynamic stabilization of the trunk. The prerequisite is the absence of more severe respiratory or skin problems. Indications are flexible or structural neuromuscular spinal instability, contraindication is idiopathic scoliosis [14–16].

The simplest form of compression-stimulating orthosis is the dynamic insole (sensorimotor, proprioceptive, or functional corrective insole), of which around 200 different types are currently commercially available (MBI, Derks, podological insoles, spiral-dynamic insoles, Jahrling, Pomarino, etc.). Studies should take into account the different designs and the need for differentiation [17]. The current study situation confirms evidence of a qualitative improvement in standing and walking function and muscle tone regulation through the activation of individual muscles by proprioceptively effective stimuli on the sole. Significant quantitative changes compared to a control group have not yet been found in 3D gait analysis studies. The prerequisite is sufficient function of the afferents without severe structural misalignment. Dynamic foot orthoses are indicated for flexible pointed, flat, hollow, and club feet, but are contraindicated in the absence of surface sensitivity or severe contractural foot malalignment [18, 19].

For ambulatory patients with cerebral movement disorders, dynamic short ankle-foot orthoses (DAFO) with a flexible ring-shaped frame that stabilize the lower ankle joint have been developed as an alternative to orthopedic footwear by the principle of „dynamic stability“. They are based on the same mechanism of action as the dynamic insole in combination with mechanical stabilization of the lower ankle joint. Indications are unstable but still flexible pointed, flat, hollow, and club feet, but they are contraindicated in severe flexible and structurally fixed feet or contractures [20, 21] (Fig. 5). Dynamic lower leg walking orthoses (ankle foot orthosis, AFO) can make an equally significant contribution to reducing pain and improving standing and walking function in patients with cerebral

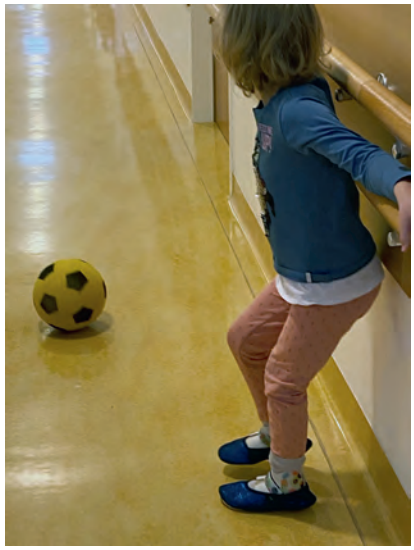

***Fig. 5*** *Dynamic ankle-foot orthoses utilize the principle of sensory stimulation of the sole and foot muscles in combination with the mechanical stability of the lower ankle joint to strengthen the leg muscles.*

*Fig. 6 Dynamic standing orthoses utilize the principle of sensory stimulation of the trunk and legs in combination with minimal mechanical stability to activate the tonic postural muscles across the pelvis.*

movement disorders and instability or (neuro-)muscular dysfunction of the upper ankle joint (OSG)/knee joint without severe structural foot malalignment by stabilizing the lower ankle joint (USG) and OSG and shifting the knee joint back along the entire leg axis. Indications are toe bunion, stepper, crouch, hook gait with/without slight drop, pointed, flat, hollow, and club feet, contraindications are structural foot malformation or position and contractures. The positive results of the first family-centered studies are interesting [22].

In patients who are unable to walk, sensorimotor learning can be achieved through proprioceptive input with dynamic whole-body standing orthoses (trunk hip knee ankle foot orthosis, THKAFO). With sufficient head control, strengthening of the tonic postural muscles can be achieved through mobile stabilization of the trunk and leg axes in cases of tetraparesis or tetraplegia with instability or neuromuscular dysfunction of the trunk-pelvis-leg joints and weight-related up to the age of around 12 years (Fig. 6). Contraindications here are also severe structural deformities and contractures. Recent studies show a sustained improvement in hip development even after 7 years with 15–30° abduction and at least 10 hours of standing therapy per week [23] and a reduction in hip dislocations requiring surgery with early treatment in the first years of life [24].

For senso orthoses based on dynamic stability, quality criteria also make it easier to assess the effectiveness and significance in the overall treatment concept: dynamic orthoses, ankle-foot orthoses, dynamic standing orthoses, and trunk orthoses are individually model-moulded and, in conjunction with therapy and everyday activities, should enable training of the mechanoreceptors and the afferent system as well as undisturbed mobility with strengthening of the muscles with corrected lever arms in the neutral position of the joints. The reported functional improvement and positive reception by patients, the assessment of ADL tasks, the visual and instrumental measurement of posture and gait parameters, and the long-term development of the locomotor system provide indications of the desired effectiveness.

## How do senso orthoses work with electrical stimulation?

In contrast to compression, electrostimulation can be used therapeutically for cerebral movement disorders with an even stronger application of stimuli to the receptors and can trigger multiple subjective and objectively measurable effects. Electrotherapy can be used to reduce pain, stimulate innervated weak muscles, increase neuroplasticity, and reduce spasticity.

Pain reduction and thus an improvement in movement can be achieved by swelling current using surface electrodes and is used, for example, for shoulder dislocation following an insult.

Stimulation of centrally paralyzed muscles and muscle strengthening of weak muscles in central paresis is achieved by electrostimulation using threshold training. It is used clinically with the aid of EMG-triggered electrical stimulation, e. g. for the triceps brachii or tibialis anterior muscle.

Electrical stimulation also enables tone reduction in spastic paresis. Peripheral repetitive sub-sensory stimulation responds to proprioceptive afferents and is applied using gloves or socks twice a day for 20-30 min. 0.3 ms at 30 Hz sub-sensory to reduce spasticity [25, 26].

Electrical stimulation also enables activation of the brain and neuronal networking in cerebral movement disorders. Sensory afferent stimulation is used to promote neuroplasticity and increase sensitivity [27].

High tone therapy can be used by simultaneous frequency and amplitude modulation with sinusoidal, metal-compatible alternating current with frequencies of 4000–33000 Hz and up to 300 mA. Indications include cerebral palsy following an insult and multiple sclerosis, whereby home devices are suitable for daily use with longer therapy durations [28].

It is important to note that the effect of sensory orthoses through electrical stimulation can vary from person to person and depends on various factors such as the localization and extent of the primary damage, the type of cerebral movement disorder and paralysis as well as the individual course of the disease.

## Development of electrical stimulation orthoses for cerebral movement disorders

To date, various electrical stimulation orthoses have been developed for cerebral movement disorders. Functional electrical stimulation (FES), in which electrical impulses are used to stimulate weakened or paralyzed muscles, has been used clinically for the longest time. This type of orthosis can be used in patients with cerebral movement disorders to support movement and improve muscle strength.

Functional electrical stimulation is successfully used with stimulation cuffs on the forearm, thigh, and lower leg to activate the long muscles of the hand, leg, and foot. Indications include weakness of the wrist extensors, knee extensors, knee flexors, pronators, and foot lifting muscles following an insult, unilateral cerebral pal-

sy, and multiple sclerosis. Contraindications are structural malpositions and a lack of subjective acceptance on the part of the wearer.

In the systems for the lower extremities, such as „Bioness“, „Alfess“ and „WalkAide“, movement sensors detect the position of the leg in the gait cycle and trigger the correct stimulation time. The fully replaced function can be documented in the 3D movement analysis.

Systems for the upper extremities are more suitable for therapeutic applications. „Bioness H200“, for example, is triggered with the contralateral hand via remote control, while the „Regrasp movement sensor“ is triggered behind the auricle when the head nods.

The effectiveness and therapeutic benefits of stimulation orthoses [29, 30] and neuroprostheses [31] for patients with cerebral movement disorders following an insult have been documented in numerous studies for decades. The systems are not considered suitable for all patients by centers experienced in the clinical application; extensive testing and correct adjustment are essential in any case [32]. Quality criteria: Cuffs with functional electrical stimulation are intended to replace missing or weak muscle functions, whereby the practical benefits for patients should outweigh the somewhat laborious wearing and use of the instrumental aid in everyday life. The effect can usually be easily assessed on the upper extremities using ADL tasks and for the lower extremities using clinical or instrumental gait analysis.

Another type of electrical stimulation orthoses are sensory orthoses, which have been specially developed for the treatment of sensory disorders. These orthoses use electrical impulses to improve sensory perception and promote proprioceptive abilities. They can be used in patients with cerebral movement disorders to improve body awareness and balance.

Sub-sensory stimulation, which leads to tone regulation and spasticity reduction by addressing proprioceptive afferents, is applied by the neuromodulation whole-body compression and e-stimulation orthosis „Exopulse Mollii Suit“. This form of electrical stimulation using surface electrodes is a non-invasive therapeutic technique for improving voluntary motor control and reducing pain and spasticity in patients with cerebral movement disorders. One advantage is better compliance, as patients do not feel the impulses, unlike with FES. This system is a tight-fitting full-body suit with integrated electrodes designed for self-administered electrical stimulation to reduce spasticity and promote mobility. 58 embedded electrodes stimulate at 20 Hz and control 40 myotomes or muscle groups via dermatomes (Fig. 7).

The mode of action of this senso orthosis, in which low frequencies with low intensity cause sensory input but do not trigger muscle contractions, is not fully understood. The theoretical background of this method relates primarily to the concept of reciprocal inhibition, i.e. that the sensory input of a muscle can inhibit the activation of an antagonistic muscle by activating disynaptic reciprocal Ia afferents. In the neurophysiological mechanism of antagonist inhibition, subliminal electrical impulses therefore reach the corresponding spinal segments via tactile cutaneous nerves without involving the motor parts, are connected, and trigger inhibition of the antagonist in the Renshaw interneuron without triggering a muscle contraction.

The aim of this senso orthosis is therefore to stimulate an antagonistic muscle (e. g. foot lifter) to reduce the reflex-mediated overactivity of an antagonistic muscle (e. g. plantar flexor) by inducing reciprocal inhibition. However, as with conventional low-intensity TENS, other mechanisms may also play a role (33).

The „Exopulse Mollii Suit“ has been evaluated in several clinical field reports with positive results, indicating its potential for rehabilitation. A recent review [34] examined its effectiveness for rehabilitation and patient acceptance, showing that the positive effects of the neuromodulation whole-body compression orthosis on improving motor function and reducing spasticity are related to the duration of administration and the dosage of treatment, which in turn depend on the severity of the patient‘s impairment and their treatment goals [35].

The majority of patients report positive effects that occur spontaneously or after a few hours. They observed

***Fig. 7*** *Neuromodulation whole-body compression and e-stimulation orthoses utilize the principle of sensory stimulation through compression and electrical stimulation with multiple effects on the addressed muscles.*

improved coordination of movement, better sleep, and relaxation of the muscles. To date, no negative effects have been reported by patients or practitioners [36].

As these subjective and objective improvements are not observed in all patients, further studies are needed to precisely define indications and contraindications.

At present, testing can be recommended for children and adults with cerebral movement disorders following an insult, traumatic brain injury, cerebral palsy, and multiple sclerosis. The manufacturer specifies electronic implants, life-support devices, and devices that are operated in the high-frequency range, together with ECG devices and pregnancy as contraindications. The orthosis would be relatively contraindicated in cases of epilepsy, cardiovascular, oncological, skin, and infectious diseases as well as after surgical procedures.

## Experience with the use of senso orthoses and outlook

In principle, the range of indications for senso orthoses includes infants, children, adolescents, and adults with cerebral movement disorders at all

levels of gross motor function. They can be used in therapy settings or for everyday activities. The prerequisites for use are sufficient head control and surface sensitivity, sufficient activation and strength of the tonic and/or phasic musculature, and no or only slightly advanced structural changes to the musculoskeletal system to achieve a largely neutral position of the spinal and limb joints with physiological lever arms of the musculature in the orthosis.

In centers that care for children and adolescents with cerebral palsy, experience with senso orthoses during therapy and when used at home has been gained over decades. As part of physiotherapy and at neuro-orthopaedic team meetings, the additional use is initially discussed together following a detailed history of regular activities and a clinical examination. The expected benefits, such as improved strength development, more independence, and greater mobility, are weighed up against possible problems, such as restrictions and effort in everyday family life.

Senso orthoses based on the principle of dynamic stability, such as foot, trunk, and whole-body orthoses, are then prescribed and customized and are adopted as part of a team during aid monitoring appointments, where the fit, acceptance, and effectiveness are assessed and evaluated at intervals of around 3–4 months.

Compression orthoses and e-stimulation orthoses are ordered or made to measure and should be tested in advance. Orthopaedic technicians offer appointments for testing during therapy and/or at home. Ideally, the senso orthoses are tested by the treatment team for fit and acceptance, and the effect is jointly assessed after approximately 30–60 minutes of use based on quantitative parameters such as walking distance, gait speed, spinal alignment and dexterity, and qualitative parameters such as gait pattern, posture, and hand function. Photographs or films of the gait pattern, everyday activities, and/or gripping function are taken before and after testing in the frontal and sagittal planes and shared with the treatment team. If the objective and subjective assessment is positive, the senso orthosis is then prescribed, adapted, and adopted.

## Conclusion

In contrast to the numerous user reports, scientific studies on senso orthoses are still rare. These describe improvements in various mobility scores, behavior, motivation, and participation in a high percentage of patients. No disadvantages or unfavorable effects of using senso orthoses have been reported. This also corresponds to the experience of our clinic and the facilities we support with all the models mentioned. We have consistently seen good acceptance of compression and electrical stimulation orthoses by patients and their families after a short trial period of a few days. With regular use of compression orthoses for at least 30–60 minutes a day, we have seen improvements in joint mobility, joint development, motor function, and daily activities in most patients, depending on the motor disorder, but independent of the model used. With electrical stimulation orthoses, we were also able to observe these improvements in some of the patients. However, we believe that testing is essential before the specific treatment indication.

Precise information on indications, especially for orthoses with electrical stimulation, cannot yet be given based on the current state of the scientific literature and clinical experience. Further studies on the function of the sensorimotor system are necessary to understand how exteroceptive and proprioceptive input are processed centrally and contribute to posture and movement control under physiological and pathological conditions. In the meantime, more experience reports with individual senso orthoses and in individual clinical pictures in childhood and adulthood could help to narrow down the indications and contraindications more precisely and help the treatment team to make clinical decisions about which children and adults with cerebral movement disorders benefit best from which senso orthoses.

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# Sport as Therapy and the Dream of a Paralympic Gold Medal

**The 2024 Paralympics begin in Paris on August 28 – a special event for all participating athletes, especially for the athletes from the host country, France. One of them is Abel Aber, who dreams of winning the gold medal in canoeing. In this interview, the Frenchman, who has a single lower-limp amputation as a result of a scooter accident, talks about his sporting goals and how his prosthetist once helped him to overcome his trauma.**

*OT Media: When and why did you have your amputation?*

**Abel Aber:** My femoral amputation took place in 2003, when I was 17. It was the result of a scooter accident.

*OT Media: After your amputation, what was your orthopedic treatment like?*

**Aber:** The orthopedic treatment was very complicated because I wasn't receptive to getting back on my feet. That's why I didn't go to a rehabilitation center. So, I was on crutches for two years. Mentally I wasn't doing well at all, and I had a lot of trouble accepting my amputation.

One day, a friend told me about boxing. But it was complicated on one leg, so I tried to get back on my two legs. That's when I met my prosthetist, with whom I got on well. At that point, I still wasn't ready to accept it, but my prosthetist understood that very well and was able to adapt to my psychological condition. Step by step, I began to accept wearing my prosthesis, even though it took a long time. Time for me to accept it. So, I could say that sport has really been my rehabilitation. As I often say: Sport is my therapy!

*OT Media: What role did your prosthesis play in this?*

**Aber:** With time and acceptation, I got more and more used to walking with the prosthesis and my prosthetist was able to gradually adapt it to my needs. Now I wear my prosthesis all the time and I'm very active. That's why the components must be resistant to my active life. For the past 2 years, I've been fitted with the Proteor "Quattro" knee for everyday use, and it has changed my life because I no longer have any limits. What's more, as sport is very important to me, my prosthetist had to make me rapidly a specific prosthesis for boxing.

*OT Media: You play several sports. When did you switch from (Thai) boxing to canoeing and kayaking?*

**Aber:** As soon as I was able to get back on my feet in 2006, I started boxing and it's been a real school of life for me. The sport helped me to channel my energy. I got into several coaching qualifications, and I also practiced boxing. I always wanted to go further in my performances and my challenge was to get into the ring as a person with an orthopedic treatment. I continued this sport for several years, until 2018 when I went up against able-bodied amateurs in English boxing. It was a great victory for me, but it required a lot of commitment and consistency.


Photos [2]: Abel Aber

*Through boxing and an empathetic prosthetist, Abel Aber learned to deal with wearing a prosthesis.*


*Frenchman Abel Aber will compete in the "canoeing" sprint discipline at 2024 Paralympics in Paris.*

*OT Media: Why did you then decide to change sports?*

**Aber:** With the Paralympics coming up in Paris in 2024, I wanted to be part of the event. Boxing wasn't one of the Paralympic disciplines, so I took part in a screening by the French Paralympic Sports Committee and discovered the para-canoe sprint discipline in 2019. It was a new challenge for me. I got seriously involved in this sport from 2020. After a lot of hard work, I'm now number one in France and in the top eight in the world, which gives me the "elite status". It's a very explosive and challenging discipline, that's what I love about it.

*OT Media: Does your health insurance cover treatment for a waterproof prosthesis in general?*

**Aber:** Sports prosthesis are not reimbursed in France but fortunately Proteor supported me in 2017 by offering me the "Easy Ride" knee and a foot from the "Rushfoot" range. It's a foot that's unbreakable, lightweight and above all waterproof, so very practical in sport. Since then, I've been able to invest myself and perform even better.

*OT Media: Why do you remove your prosthesis before canoeing?*

**Aber:** I don't need a prosthesis for the canoe. I just need to keep the stump in place, and that's very important.

*OT Media: What is the status of Paralympic sport in France and can we expect the public to be as enthusiastic about the Paralympic Games in Paris as they were in London in 2012?*

**Aber:** The Paralympic Games will be a great opportunity to highlight French and international athletes. It'll be an opportunity to showcase all our disciplines and show that we're there, that we want to win. I think people will be there to support us. I can't wait to see the atmosphere in Paris. Having the Paralympics in our country is incredible.

*OT Media: What support are you getting from the French Paralympic Association?*

**Aber:** Sport in France is not professional, so you have to be motivated, determined and manage to find sponsors.

*OT Media: What are your personal goals for the Paralympic Games and beyond?*

**Aber:** I'd like to win gold at the Paralympics. It could also be a great form of revenge and a springboard for me. So it's another challenge that's positive both physically and mentally. Nothing is impossible, so I'm going to give the best of me to win this medal and have no regrets!

*The questions were asked by Michael Blatt.*

*The P&O "champions" class of 2023 with their project degrees.*

# Mongolia Takes Steps to **Strengthening** P&O Services

Mongolia is a country twice the size of France, but with a population of only 3,3 million people – of whom half are dispersed over 21 provinces, and half live in Ulaanbaatar, the capital city. Prosthetics and orthotics (P&O) treatment are currently available at only two government centres under the social welfare sector (one serving only children) and one private centre. Hospitals do not yet offer ortheses in acute or subacute treatment and such assistive technology is not allowed for in the national health insurance scheme.

But times are changing. Organizations of persons with disabilities are calling for access to modern assistive products and timely service provision. Having completed the WHO assistive technology surveys in recent years, the needs are well-recognized. Indeed, assistive technology is written into the Law for the Protection of Persons with Disabilities, and into various rehabilitation strategic documents, but the complexity of the assistive technology sector is challenging. Multi-sectoral agreement, an integrated development plan and of course funding allocation are all required. In many situations a call for donations of equipment or devices seems the simplest solution but of course this doesn't solve the problems of a sustainable P&O treatment.

The Mongolian Society for Physical Rehabilitation and Medicine (MSPRM) recognizes that P&O requires personnel with both clinical and technical education, as a key component of any strategy. The P&O specialist must be appreciated as a full member of the rehabilitation team. MSPRM is thus taking small steps to "prepare and seed the field", while consensus on a national assistive technology strategy is building. One step has been to invite Human Study e. V., a German P&O education NGO, to help them plan and cultivate "champions" from the rehabilitation professions, by holding short trainings, while simultaneously stimulating an interest among young people in undertaking a degree in P&O.

The project began with a stakeholders' forum September 2022 where Christian Schlierf of Human Study, pre-

*Orthotics treatment is very rare in Mongolia.*

## Interdisciplinary Introduction to DAFOs for Children with Cerebral Palsy

- 6 weeks online self-study/tests of biomechanics etc.
- 2-day workshop: 6 children assessed, prescribe, castings, retification
- 5-day workshop: 6 children assessed, fitted, integrated rehab plans made
- Participants selected own case to prescribe and make orthosis for online presentation

*The P&O project generated a great deal of interest among the workshop participants.*

Photos: Mongolian Society for Physical Rehabilitation and Medicine

*A direct patient treatment was also included in the workshop.*

sented on prosthetics and orthotics, and estimates of need for personnel based on the population in Mongolia. A year later, MSPRM and Human Study (HS) organized a hybrid, interdisciplinary training course (with translation) on dynamic ankle and foot orthoses for children with cerebral palsy. Fifty participants completed the 6 weeks online theoretical part. Nineteen participants completed the workshop of 7 days, taught by HS volunteer experts working with 6 children. In the process of providing the six children with orthoses, the interaction of the physical therapies and orthoses prescription and revisions were clearly absorbed. The final part of the training over 3 months, included 7 rehabilitation doctors together with their physical therapists, selecting a child from their practice in need of an ankle foot orthosis. Together with the orthotist (who attended the workshop), they worked through the process and then presented the outcomes. They agreed that this independent self-learning helped them to deeply understand how much more they needed to know and practice.

The principal aims of this introductory effort were:
- to stimulate interest in the integration of the clinical and technical aspects of P&O provision
- to raise awareness of the complexity of prescription, making and revising orthoses for optimal functioning
- to demonstrate interdisciplinary teamwork

The feedback was overwhelmingly positive. “If you take this course every year, thousands of children with paralysis in Mongolia will benefit”, said one attendee afterwards.

Further interdisciplinary training is planned for 2024 and 2025 to continue sowing seeds and cultivating the prosthetics and orthotics field as an integral aspect of rehabilitation in Mongolia. The MSPRM is now searching for scholarships to support 2 or 3 young persons, who have demonstrated interest, to study for formal P&O degrees, in a regional country. In parallel, the MSPRM is working with different sectors to increase awareness of the need for a national, multisectoral strategy for assistive technology, including prosthetists and orthotists.

*Dr. Zolzaya Batdavaajav, MSPRM President;*
*Sheila Purves, MSPRM Advisor*


## Acknowledgements

We want to thank the Mongolia National Rehabilitation and Development Center for Children with Disabilities, who hosted the workshop, the volunteer teaching experts and staff of Human Study, the local Mongolian doctors and therapists who translated both materials and classes, and the children and their parents who willingly co-operated with us.

# Orthotics

**F. Braatz**

## Does Stance and Swing Phase Control Provide an Advantage for KAFO Wearers? Results of an International Randomised Controlled Trial

The C-Brace microprocessor-controlled stance and swing phase control orthosis is designed to overcome the safety and functional limitations of traditional knee-ankle-foot orthoses (KAFOs) for individuals with lower limb paralysis. However, a systematic comparison with established KAFO types had not yet been carried out in a larger sample. To compare the different types of orthoses, an international multicentre, randomised, controlled crossover study was conducted. Experienced KAFO users with a high risk of falling were randomised and assigned to the KAFO/C-Brace or C-Brace/KAFO groups for three months with each orthosis. The primary endpoint was the assessment of balance using the Berg Balance Scale (BBS). Secondary outcomes included the number of falls, reduction in fear of falling and improvement in mobility, function and quality of life. Data from 102 participants were evaluated in the intention-to-treat analysis; data from 69 participants were available for the per-protocol analysis. With the C-Brace, the BBS score improved by 3.3 ± 6.3 points ($p < 0.0001$). Significantly fewer participants had BBS values <40, a value that indicates an increased risk of falling (16 vs. 36, $p = 0.018$). The number of falls decreased on average from 4.0 ± 16.8 to 1.1 ± 3.3 ($p = 0.002$). The results for function, mobility and quality of life showed significant improvements with the C-Brace. The improvements in risk of falling and mobility are due to the controlled knee flexion under loading with the C-Brace and have a positive effect on the quality of life of the users. The C-Brace is therefore a safe and effective option for KAFO users with an increased risk of falling and limited mobility.

**Key words:** KAFO, knee-ankle-foot orthosis, stance and swing phase control orthosis, C-Brace, falls, risk of falling, quality of life, balance, mobility

Abstract from: ORTHOPÄDIE TECHNIK 04/2024, Page 56 – 66

# Neuro Orthopaedics

**S. Rudolph**

## Dynamic CDS Knee Redression Orthoses for Children and Adolescents with Cerebral Palsy GMFCS Level II–III

The problem presented here involves the occurrence of knee flexion contractures caused by muscle imbalances, shortened and spastic muscles of the knee joint and a prolonged sitting position. These contractures lead to a knee extension deficit and can result in incipient crouch gait with instability in the gait cycle and difficulties standing and walking. The dynamic stretching of contracted muscles is an important treatment approach for treating contractures of the lower limbs in children and adolescents with cerebral palsy. The objective of this pilot study was to examine whether the use of albrecht CDS knee redression orthoses combined with adaptation of the spring force can contribute to reducing the knee extension deficits or counteracting deterioration.

**Key words:** CDS Knee Redression Orthoses, Knee Flexion Contractures, GMFCS Level II–III, Knee Extension Deficit, Cerebral Palsy, Spring Force, Dynamic Stretching, Stretching/Load Limit, Orthotimer Wear Time System

Abstract from: ORTHOPÄDIE TECHNIK 04/2024, Page 68 – 77

# Pedorthics

**K. Zink, J. Stumpf, T. Haak**

## Pressure Relief in Diabetic Foot Syndrome – Presentation of the Current Guideline of the International Working Group on the Diabetic Foot (IWGDF)

Diabetic foot syndrome (DFS) is a chronic, incurable disease with an annual recurrence rate of 40% and 65% after three years. In affected patients, the neuropathy as an underlying disease has reached an extreme extent and led to the complete loss of protective sensation (LOPS) of the feet. In addition, there are motor disorders with muscular dysbalances and imbalances, which lead to plantar pressure increases on the sole of the foot and to deformities. The tissue is damaged by repetitive trauma to the foot caused by these pressure increases. Autonomic polyneuropathy reduces sweat secretion and thus increases the vulnerability and fragility of the horny layer of the sole of the foot. In about half of the patients affected, peripheral arterial occlusive disease (PAVD) is also present, which delays the healing of the resulting wounds or even makes it impossible. Therefore, like a Charcot foot, it must also be monitored and, if necessary, treated. These manifold problems show that the diabetic foot syndrome can only be treated adequately in an interdisciplinary team. The article presents suitable measures for pressure relief based on the current guideline of the International Working Group on the Diabetic Foot (IWGDF) and focuses on predominantly neuropathic and non-infected foot wounds.

**Key words:** diabetic foot syndrome, plantar pressure, ulcer, pressure relief, device

Abstract from: ORTHOPÄDIE TECHNIK 04/2023, Page 44 – 48

# HowToTreat

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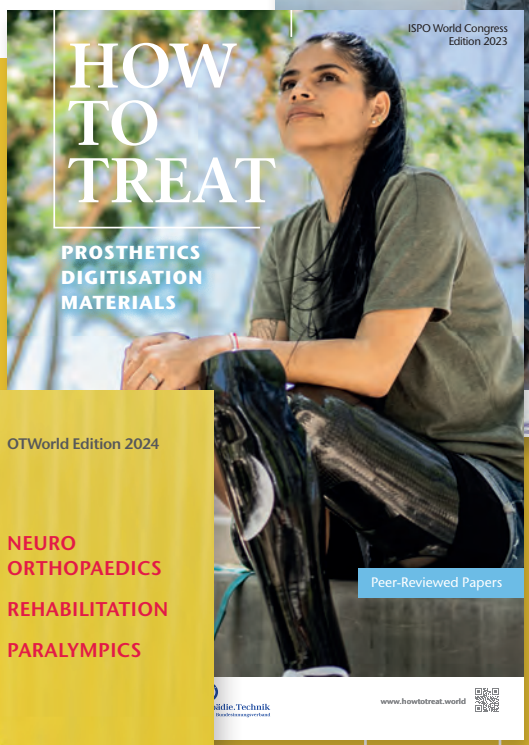


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Photos [3]: Ottobock

*The first technical repair service centre container was sent from the Ottobock Campus in Duderstadt to Lviv in Ukraine in September 2022.*

# **Expansion** of Orthopaedic Technology Infrastructure in the Ukraine

To give war veterans in Ukraine new hope, the med-tech company Ottobock is supporting the development of medical technology infrastructure on site in a variety of ways. One focus is a comprehensive training and continuing education programme for Ukrainian orthopaedic professionals. "We're putting tireless effort into working with our partners to provide amputees with prostheses and give them new hope", says Tim Schäfer, Regional President EEMEA at Ottobock.

In close cooperation with international aid organisations such as the Red Cross and Malteser International, Ottobock has already begun implementing various technical repair service centre projects in 2022, such as the placement of a mobile technical repair service centre in Lviv, followed by four further containers in Kiev, as well as orthopaedic technical repair service centres connected to hospitals.

*Borysov Oleksii from Khmelnytskyi trains his orthopaedic technology skills at the Ottobock Campus in Duderstadt.*

In addition, Ottobock is addressing the shortage of orthopaedic technology specialists in Ukraine together with Ukrainian non-profit organisations such as Superhumans and long-standing customers. Founded in April 2023, the Superhumans Center in Lviv has a trauma ward for war victims and a prosthetics centre with a rehabilitation unit. The centre staff includes, among others, Ukrainian orthopaedic technicians and physiotherapists trained by Ottobock last year.

The German company also achieved a product milestone in the summer of 2023. In the "Hand reimagined" project, the development team quickly developed a passive, waterproof functional aid made of silicone for everyday use at home and for personal hygiene: the Skeo Up Daily Assist.

## Specialist expertise for Ukraine

The Ottobock Global Academy offers training and continuing education for Ukrainian orthopaedic professionals on a regular basis throughout Europe. The courses offered range from intensive courses to certification and continuing education to a year-round training programme at the International O&P School in Duderstadt. By providing additional digital training, Ottobock is responding to the more challenging departure conditions for Ukrainians.

Most recently, ten Ukrainian technicians from the partner companies Superhumans, Avanti, Forward Orto and Halychina took part in the Lower Limb Prosthetics Crash Course at the Ottobock Campus in Duderstadt. "Our goal was to enable the participants to treat people with transfemoral and transtibial amputations within 12 weeks. The special challenge is that different levels of experience require flexibility in planning," explain Markus Goldmann

*Trainer Markus Goldmann (l.) shows participants how to optimally align a prosthesis using the 3D L.A.S.A.R. Posture measuring device.*

and Frederik Thiede, who were in charge of the training course. In order to cover the entire range of topics, a team of eight additional trainers with different emphases was involved. Throughout the training, they were accompanied by an interpreter to overcome language barriers.

Following theoretical instructions and an overview of Ottobock products and fitting solutions, the participants put their expertise into practice directly on the demo user. "With a total of nine fittings per person, we put a key focus on practical training so we could raise them to a common level for their work in Ukraine," says Thiede.

From plaster modelling for the socket to plastics processing to the fitting, the participants went through each prosthetic fitting step by step. They were introduced to a wide variety of materials and machines. A further focal point was the organisation of an orthopaedic technical repair service centre, where every tool has a permanent place. They are now putting their know-how into practice in Ukraine under expert supervision.

*Transparency notice*

This article was realised in co-operation with Ottobock. →

*OT Media: Mr. Schaefer, what kind of network did Ottobock have in Ukraine before 2022, when Russia intensified its military aggression, and how have you as company expanded your activities in the last two years?*

**Tim Schäfer:** We have long-standing relationships with our customers in Ukraine. We were already supplying the market with our products and conducting international training sessions prior to 2022, but at that time also in Ukraine with participants of several nationalities. In the last two years, the need for trained orthopaedic technicians as well as medical technology devices has increased significantly. In order to meet these needs, we focused on continuing to expand our orthopaedic technology infrastructure and expanding partnerships with newly established organisations. At the same time, we expanded our range of training courses to counteract the shortage of skilled workers by transferring knowledge.

*OT Media: Fortunately, war injuries were hardly part of the treatment spectrum of doctors and prosthetists in Europe - what makes their treatment so challenging and special?*

**Schäfer:** Over the past two years, orthopaedic professionals have increasingly be faced with war injuries from shrapnel and burns. These are often accompanied by inflammation and pronounced scarring, which in some cases require re-amputation. This, in turn, means patients often have very short residual limbs, which are much harder to treat. Many of them are young multiple amputees. In addition, the number of amputations in the upper limb region increases considerably compared to other countries. However, due to the unpredictable situation, we are not only challenged professionally, but also, above all, on a humanitarian level. Empathy and comprehensive psychological support are essential when it comes to the treatment of victims of war. The motivation to become active again is indispensable for successful treatment and reintegration. We work together with doctors and therapists on an interdisciplinary approach to achieve comprehensive rehabilitation.

*The "Skeo Up Daily Assist" was developed from a research prototype to a medical device within four months.*

Photos [2]: Ottobock

*Tim Schäfer, Regional President EEMEA at Ottobock, reports about the treatment situation in Ukraine.*

*OT Media: What access do P&O professionals and patients have to prostheses and orthoses that are widely used in the European Union, for example?*

**Schäfer:** The reimbursement situation in Ukraine is very good for Eastern European standards. Veterans in particular are entitled to high-quality medical technology treatment and therefore to nearly all Ottobock products.

*OT Media: What exactly is the "Skeo Up Daily Assist" functional aid all about?*

**Schäfer:** After an amputation, it is very important to resume or learn everyday activities as soon as possible. We developed the Skeo Up Daily Assist as a new product category in less than four months with the goal of providing people in crisis regions with uncomplicated, quick treatment of upper limbs. Specifically, it is a passive, waterproof functional aid made of silicone for daily personal hygiene. It is used like a liner as an initial or additional fitting. An integrated clamp adapter helps users grasp, hold and finally use objects such as toothbrushes, shampoo bottles or razors.

*OT Media: What are the goals and specific tasks of the foreign subsidiary in Ukraine established by Ottobock in late 2023?*

**Schäfer**: In establishing our own foreign subsidiary, we started by creating the prerequisites for developing storage facilities so we can faster provide frequently needed products to our customers. Taking into account the current situation, we are gradually expanding this branch logistically and in terms of personnel. In the long term, we are planning to employ 20 local employees in field service, socket production and administration in order to further expand our sales structures and create training opportunities later on.

*The questions were asked by Michael Blatt.*

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# Creating a Fully Functional **Prosthesis** – On-Site, On-Demand, Personalized

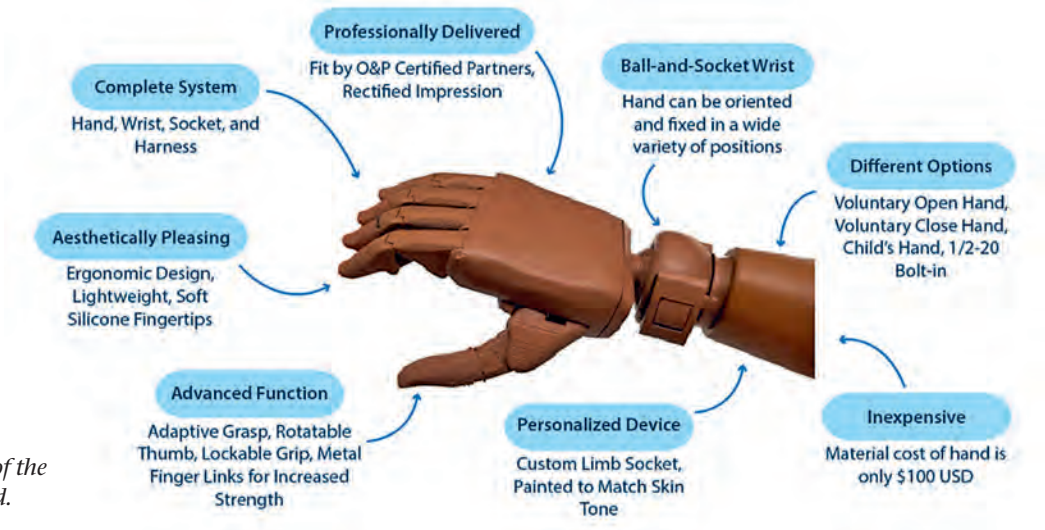
*A VHP-Collaboration with a clinic in Kenya.*

The World Health Organization estimates that 2.4 million of the 3 million upper-limb amputees worldwide live in developing countries, yet only 5% of this population has access to prosthetic care [1], [2]. Governments and public healthcare systems in developing countries cannot cover the high costs of prosthetic devices, and with many people in these areas relying on labor-intensive occupations for their primary source of income, upper-limb amputations can leave families entrenched in a cycle of poverty [2]. Victoria Hand Project (VHP), a Canadian charity and non-profit organization, has a mission to provide upper-limb prostheses to amputees with limited or no access to prosthetic care.

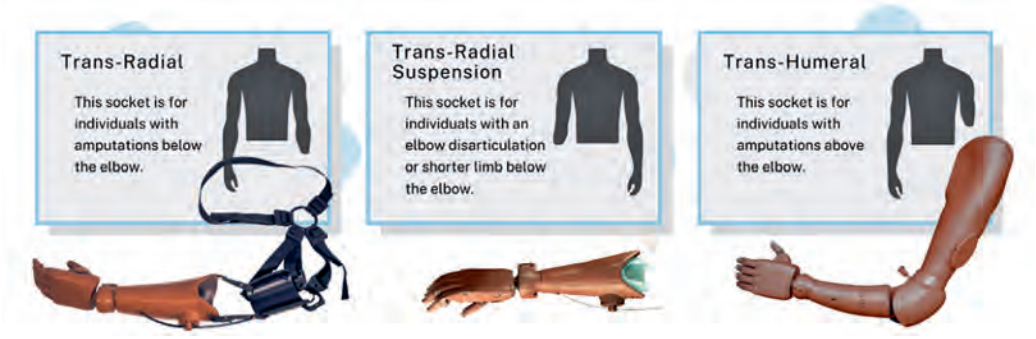
The result of years of engineering and development is a low-cost, highly–functional, 3D-printed upper-limb prosthesis: The Victoria Hand. By combining advanced and cost-effective tools – Additive Manufacturing, 3D scanning, and 3D software – the Victoria Hand is fabricated directly within the countries where they are needed and used. In collaboration with a network of international clinical partners and healthcare providers, the Victoria Hand is made available to amputees throughout the world.

The Victoria Hand is a complete system, comprising the hand, wrist, socket, and harness. It provides advanced functionality with an adaptive grasp, a rotatable thumb, a lockable grip, and metal finger links for increased strength. A user can adduct or abduct the thumb, to achieve different positions for many different grasps, creating a hand that can assist the user for many more in their daily life. This includes a one-finger pinch, a two-finger pinch, a power grasp, or a lateral grasp.

To help as many amputees as possible with widely ranging variations in limb difference, each limb socket is completely customized to the user, using 3D scanning and 3D printing, to create a comfortable fitting socket. The printing of the components of the hand is carried out on-site in each of Victoria Hand partner clinics. The VHP team travels to these clinics and brings 3D printers and all the necessary tools to assemble the prosthetic arms. The team conducts 1-2 weeks of training with the prosthetist/technician team, teaching them how to use 3D scanners, 3D printers, and 3D design software, and covering the workflows involved in making a Victoria Hand prosthetic arm from start to finish. With this equipment and training, clinical partners can operate mostly independently, providing Victoria




*The features of the Victoria Hand.*




*The Victoria Hand can be used by people with various levels of limb difference through their advanced custom socket workflow.*

Hands to patients on an on-going basis. The 3D scanning, 3D printing, and assembly of the prosthetic hands is done on-site. VHP supports these partner clinics by providing funding, equipment, technology updates (software, workflows), design updates, and services to ensure they have everything they need to continue to serve low-income patients. VHP pays clinical partners a stipend to cover their care services and covers the costs for patients. This allows existing healthcare clinics in the countries VHP works in to be supported and grow to help more people in need.

For many amputees, having an inconspicuous prosthetic is highly valued, to avoid social stigma and unwanted attention. In addition to its natural shape, the Victoria Hand and socket are painted with colors that closely match the user's skin tone. To ensure a long-lasting finish, these hands must be printed with a high-quality material that the paint can adhere well to, without chipping off or affecting the strength.

For example using Forward AM's filament "Ultrafuse PLA", the Victoria Hand can be manufactured to last a long time in harsh environments, while having a natural look. Being one of the most widely used materials for Additive Manufacturing, Ultrafuse® PLA enables consistent quality parts, making each hand a convincing print result. Its compatibility with all open fused filament fabrication (FFF) shows a low access barrier combined with high and reliable quality. This filament is also exceptionally easy to print – perfectly suited for production in print centers in developing countries.

As it is key that the prostheses are available where they are needed, VHP cooperates with clinics in the respective countries. VHP's deployment system has three primary features:

- A transferable production and fabrication system in the countries where the prosthetic devices are needed
- Professional provision of prostheses to amputees through clinical intermediaries with medical practitioners


*The Victoria Hand Project creates a network of partners and clinics in developing countries.*

*In Ukraine, amputees are now also being treated with the Victoria Hand.*

Photos [5]: Victoria Hand Project

- Training and support of both the production network and the clinical provision network

By harnessing the benefits of Additive Manufacturing, VHP developed a fully functional, low-cost prosthesis and makes it available where it's needed – in developing countries where patients have limited to no access to healthcare systems. By building up a network of clinics and installing local print centers, amputees have access to the Victoria Hand – and a chance to regain the ability to do home or work-related tasks and improve their quality of life.

The production of the prosthetic socket is still primarily the responsibility of the prothetist. However, VHP has developed a software program to assist with the creation of a 3D printable limb socket, as an alternative to traditional manufacturing methods. The clinical partner team will use this software program to digitally design the limb socket. This process involves using patient measurements and a 3D scan of the patient's plaster limb impression. Once the design is finalized, the clinical partner team can 3D print the customized limb socket.

### *Transparency notice*

This article was realised in co-operation with the Victoria Hand Project and BASF Forward AM. ■

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Peer-Review

S. Breier[1], J. Schröter[2], S. Bayer[3], D. Trinius[4], S. Bosch[5]

# Rehabilitation After Quadruple Amputation and Fitting with a Prosthesis – a Team Effort

**The amputation of all four limbs (quadruple amputation) is rare, but the impact can be devastating. Bilateral transradial amputations impair the ability to hold and manipulate objects, thus affecting all activities of daily living. Bilateral transtibial amputations greatly impair locomotion, sitting and balance, which is supported by the legs. The loss of multiple limbs therefore has a severe impact on a person's mobility and ability to perform activities of daily living.**

**The challenges that arise after multiple amputations with prosthetic fittings are interrelated and require highly specialised interdisciplinary care. Individuals with bilateral amputations of the lower and upper limbs thus face special challenges during rehabilitation.**

**Key words:** Multiple Amputation, Sepsis, Pain Therapy, Interdisciplinary Care

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## Introduction

The most common reason for quadruple amputation is sepsis, also referred to as "blood poisoning". This is defined as life-threatening organ dysfunction due to the immune system's overreaction to an infection [1]. Based on an analysis of DRG statistics, the incidence of sepsis in Germany in 2015 was found to be 158 per 100,000 inhabitants [2]. This corresponds to approximately 130,000 patients annually. The trends between 2010 and 2015 show a 7.9 % average annual increase of sepsis patients. While mortality decreased from 47.8 % to 41.7 % during this period [2], the danger of this disease, from which almost 1 in 2 patients die despite intensive care, is evident.

During "septic shock", several vital organs such as the liver, kidneys or lungs fail simultaneously within a very short period of time, resulting in centralisation of the circulation and a significant reduction in blood flow to the periphery. In the worst case, this can lead to the death of fingers and toes or even large parts of the arms and legs, making amputations necessary.

Compared to the normal population, sepsis patients have a 3.3-fold increased risk of suffering from permanent restrictions in everyday life [3]. These can manifest as cognitive or neurological deficits as well as impaired motor function. Multiple amputations in particular lead to considerable mobility restrictions and often to post-traumatic stress disorders due to the high level of psychological stress [4]. For this reason, a family member should be involved to support the patient both in the acute hospital setting and in the subsequent rehabilitation facility. Due to the restrictive physical and psychological effects, of which there are many, intensive rehabilitation is often necessary, which extends over several months.

## Rehabilitation procedures

For limb loss, pain therapy is of great importance from the outset. Both residual limb pain and phantom limb pain must be treated appropriately. A systematic review shows that preoperative pain treatment can both reduce the risk of phantom pain and improve physical and psychological outcomes [5]. Among other factors, bilateral amputations and poor psychological outcomes are risk factors for the development of phantom pain. The complex pain aetiology must therefore be treated within the framework of interdisciplinary multi-modal pain therapy [6]. This can consist of medication such as Gabapentin, Amitriptyline, opioids or local anaesthetics as well as therapeutic modalities such as sensorimotor training, trigger point or mirror therapy, which should be started in the acute hospital setting. At the same time, the patient undergoes general roboration. As soon as patients demonstrate cardiopulmonary stability and the wound conditions are not critical, they should be transferred to a specialised rehabilitation clinic.



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Upon admission there, the objective findings of the injury pattern must be evaluated and the subjective assessments of the caregivers must first be carried out in an expertly trained team involving all of the specialist and professional groups (doctors, nursing staff, therapists, social services, psychologists, orthopaedic technicians) [7], in order to plan the next steps in the patient's mobilisation and the aids and prostheses required for this. Concomitant psychological therapy is often necessary, as self-identity is a major challenge for patients due to the drastic changes in their external body image. Furthermore, those affected are dependent on the help of others, especially at the beginning of rehabilitation, and experience this as dependency or helplessness.

It is essential to involve the patient and their family members as early as possible in the care process and the provision of information. A treatment plan prepared by the above-mentioned team for each patient serves as a guideline for individual patient care. It forms the basis for achieving the defined short and long-term goals for activities and participation that the patient needs and would like to achieve. The responsible specialist in orthopaedics/trauma surgery/rehabilitation medicine is responsible for coordinating the course of treatment. In order to ensure consistency in treatment, it has proven to be useful to develop a standardized procedure. During the entire rehabilitation phase, the treatment plan is coordinated between all those involved in regular team meetings (1–2 times a week), always in accordance with the patient's progress.

The initial focus is on conditioning the residual limbs and the first fitting with interim prostheses (Fig. 1). As amputations in the lower extremities usually involve the foot or lower leg (transtibial) without loss of knee joint function, in these cases it is advisable to start treatment in order to help the patient gain more independence and the associated increase in mobility.

## Case study

The particular importance of an inpatient rehabilitation programme tailored to the patient's individual needs is explained in more detail using a case study:

In January 2022, the male patient, who was 33 years old at the time, suffered a fracture of the greater tubercle and an anterior shoulder dislocation on the right. The shoulder was repositioned and two weeks later a plate osteosynthesis was performed. Shoulder joint empyema with fulminant sepsis developed, whereupon a surgery was performed. The sepsis (toxic shock syndrome) resulted in the need for a right wrist disarticulation one month later. A subsequent amputation with bony shortening of both forearms was then performed two weeks later due to dry necrosis caused by ischemia. In addition right transfemoral and left transtibial amputations were performed.

The patient subsequently developed quadriparesis and depression. Neuropathic pain syndrome also occurred. Once the scars on the legs had healed, the first lower limp prostheses were made in hospital and two myoelectric multi-articulating prostheses were fitted for the right and left side in August 2022. In the weeks that followed, the patient was provided with an electric wheelchair and individualised aids were made to enable him to eat independently.

Upon admission to the rehabilitation clinic, the patient was able to change position independently and transfer with support. The patient received his leg prostheses as interim prostheses shortly after the rehabilitation process had started. He was able to stand unsupported at times. He was able to walk unsupported for a few metres, using forearm crutches otherwise. The 33-year-old was independently mobile in the electric wheelchair, even without prostheses.

In the rehabilitation clinic, the patient received an individualised therapy programme consisting of physiotherapy and occupational therapy, in which different treatment approaches were combined to achieve an optimal result. At the beginning of the walk training, emphasis was placed on balance training. With increasing confidence, he switched from the walking bars to forearm crutches, ultimately walking without the use of any aids and thus reaching his personal rehabilitation goal. At the same time, the patient underwent intensive occupational therapy prosthesis training for the upper limbs with the aim of achieving the best possible reintegration into social and professional life.

At the time of the incident, the patient lived with his domestic partner in a rented apartment on the 5th floor of a building with an elevator. During the rehabilitation process, the partner was already making efforts to find a new handicapped-accessible apartment. Until the medical event, the patient had been working as a design engineer for a large company. His aim was to return to his old profession. After three months, the patient was discharged from inpatient rehabilitation.

In his own words, he describes the importance of personal resilience and emotional support: "When I was first in the clinic and saw my hands and feet, I didn't know yet what the outcome would be, but I had a fear that ultimately came true. Nevertheless, I never thought that that was it, but considered how I could master all everyday situations, what 'tools' I might need and how I would have to improvise and adapt. The support of my family and my girlfriend was especially helpful to me."

***Fig. 1*** *By using interim prostheses, the residual limb can bear weight at an early stage. The first exercises involving transfer, walking and standing with the prostheses also begin.*

## Therapy goals

For those affected, a multiple amputation means that their everyday routine is completely changed in all aspects of life and they face many challenges. This profound change inevitably requires retraining and relearning, as multiple-amputees must learn to cope with their everyday lives – both with and without prostheses.

After amputation and fitting with a prosthesis, the ultimate goal for all disciplines involved in rehabilitation is to enable optimal reintegration into professional and social life. When being fitted with prostheses for the lower and upper extremities by the prosthetist, users first learn how to use them for mobility and routine everyday tasks [8]. Although there are overlaps between the therapeutic professions of physiotherapy and occupational therapy, the upper extremity, with scar treatment, desensitization, weight-bearing training, body symmetry and muscle strengthening as well as signal and functional training, is more the domain of occupational therapy. In contrast, the lower extremity with pre-prosthetic structural training, strengthening, body balance, and standing/walking training is the domain of physiotherapy.

## Occupational therapy

The general goal of occupational therapy can be described as supporting the client in the accomplishment of ADL (activities of daily living) and IADL (instrumental activities of daily living) to achieve the greatest possible independence with and without a prosthesis [8, 9].

It is important to teach independence in activities such as eating, personal hygiene, dressing, bathing, toileting, transfers, wheelchair positioning and mobility – even without a prosthesis – before starting the integration of the prosthesis into everyday life (Fig. 2). Achieving the greatest possible independence with ADLs is facilitated by wearing and operating at least one prosthetic hand. The longest residual limb often becomes the dominant hand, regardless of its status before the injury. In particular, putting on and taking off the prostheses requires dexterity, grip strength and the use of adaptive aids. The use of a dressing tree can provide support for this.

In our society, mobility or driving a vehicle is an essential prerequisite for independence and integration into society, and is therefore associated with a higher quality of life [9]. It is advisable to contact companies that specialize in adapting vehicles and driver´s rehabilitation.

Throughout the entire rehabilitation period, comprehensive information is provided on possible risk factors such as obesity, skin problems, a sedentary lifestyle and tobacco and alcohol consumption. The importance of regular fitness exercises to maintain strength and mobility and prevent the development of overuse and pain syndromes is also emphasised [9].

## Physiotherapy

The aim of physiotherapy is to enable patients to achieve the highest possible level of physical function [10]. A systematic review by Sansam et al. (2009) identifies positive and negative factors that can influence post-amputation mobility.

Positive factors include:
- distal amputation,
- intact cognitive function and memory,
- normal body-mass index and
- a high level of physical fitness and the ability to walk before the operation

The following factors have been identified as negative:
- bilateral amputation of the upper and lower limbs,
- delayed wound healing,
- dependence in the ADLs and
- inability to stand on one leg

In the therapy of multiple-amputees, particular attention should be paid to intensively practising transfer situations (e.g., moving from the bed to standing or into a wheelchair) and switching levels (e.g., standing up and sitting down) (see Fig. 1). Patients must be able to turn in bed, make the transition from lying on their back or side to sitting on the edge of the bed and maintain their balance in a sitting position without support. When standing or walking, the risk of falling increases due to a change in the body's centre of gravity or due to onset of pain. Fall prevention strategies are therefore integrated into rehabilitation at an early stage and continued throughout all phases.

For multiple-amputees, optimal mobility is achieved primarily by strengthening the trunk and proximal muscles. Since both transtibial and transfemoral amputees lack intrinsic foot and ankle control, they must rely heavily on the proximal hip muscles to maintain balance. Regaining trunk strength is also important after amputation of the upper limbs. It ensures stability, balance and correct use of the prosthesis [9].

Walk training requires support on the right and left side to ensure sym-

***Fig. 2*** *To counteract the feeling of helplessness, ADL tasks are practised without a prosthesis at an early stage.*

metry in the lower limb movements. In addition, emphasis should be placed on lateral trunk flexion and rotation as well as endurance training. After amputation of the lower limbs, the combined use of prostheses and a wheelchair should be considered for mobilisation [11]. Even in the case of bilateral amputation of the lower limbs, the aim is for clients to be able to put on and take off their prostheses independently.

## Interdisciplinary care

Bilateral amputations in the forearm (transradial) impair the ability to hold and manipulate objects and therefore affect all activities of daily living. Bilateral amputations in the lower leg area (transtibial) lead to a severe restriction of locomotion, sitting and balance, all of which are based on leg function. As a result, the loss of multiple limbs has a serious impact on a person's mobility and ability to perform activities of daily living.

The stress factors after multiple amputations with prosthetic treatment are mutually dependent and require – as described above – highly specialised interdisciplinary care. People with bilateral lower and upper limb amputations therefore face particular challenges in rehabilitation.

## Orthotic and prosthetic care

*Stephanie Bayer*

In the rehabilitation of quadruple amputees, orthotic and prosthetic services are tasked with fabricating and fitting of the respective devices to support the everyday life (see Fig. 5a). Particular attention is paid to the selection of components and suitability for everyday use. In addition, the expectations and goals that the affected person has for the aids must be mutually defined. This also includes the fact that the technology cannot meet all expectations. This must be communicated honestly and openly with the affected person in advance in order to avoid disappointment. The primary goal with multiple amputations is to ensure that the prostheses can be put on and taken off independently and are easy to handle. In addition, the prostheses must be designed as lightweight as possible and still fulfil as much function as possible. Finding this compromise is the biggest challenge for the P&O professional, apart from the fitting.

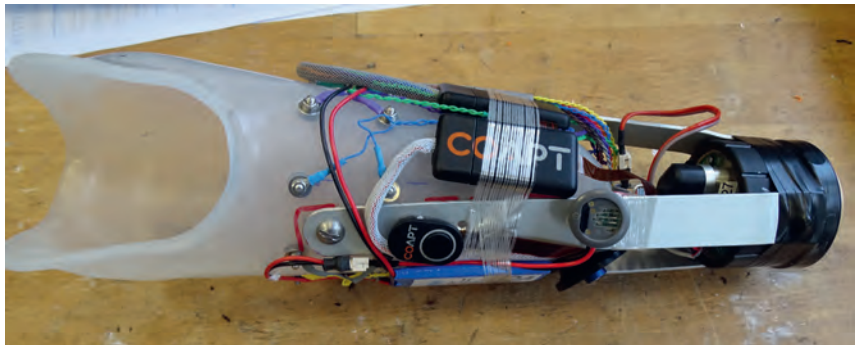

***Fig. 3*** *The transparent trial socket allows the volume and skin contact to be checked. Several electrodes record different movements and analyse them for pattern recognition.*

### Lower Limp Prostheses

The next step for the patient is to get back on their feet. So-called interim prostheses may be fitted for this purpose. These prostheses are designed in such a way that they can be quickly adapted to new circumstances. This is necessary because the residual limbs can change considerably in the first six months after an amputation. In the case described here, a weekly check and readjustment of the sockets were necessary. We also adapted the static alignment to support the patient's progress. Furthermore, we tested different components during this phase. The interim phase is defined as six months for single amputees, but this period of time is often not sufficient for multiple-amputees. We therefore extended the interim phase and built a second socket for the transfemoral prosthesis.

### Upper Limp Prostheses

We built the prosthetic arms as soon as the patient was able to walk with forearm crutches. Component selection considered the differences in limb length. On the left side (long residual forearm limb) we chose a multi-articulating hand with a two-electrode control. The socket is designed in such a way that the body's own pronation and supination can be used to position the prosthesis in all directions. A multi-articulating hand was also used on the opposite side (medium-length residual forearm limb). It is controlled by what is known as pattern recognition. This technology allows quick access to the different grip patterns and the control of a rotary motor (Fig. 3). This is a substitute for the pronation and supination movement.

As a rule, it is easier for patients to use a uniform control system, even if the conditions of the residual limbs are different. In this case, we opted for different systems per the patient's wishes; he also had the cognitive capacity to operate both prostheses.

We used silicone socket systems to ensure that the prostheses were held securely in place. This material combines high adhesion with excellent wearing comfort.

### Outlook

At the end of the interim phase, the patient was able to put on and take off all four prostheses independently without additional aids. He was able to stand unsupported with the prosthetic legs and control the prosthetic arms in order to carry out the tasks that were essential for him. We then finalised the lower limp prostheses and selected the final components. In follow up meetings with the patient and certified prosthetists and orthotists (CPO) we always ask whether the current fitting is suitable for the patient's current life circumstances. If this is no longer the case, the fitting must be adapted.

## Physiotherapy

*Doren Trinius*

The patient came to the clinic in May 2022. He was able to turn and sit up in bed without help. He already had an

*Fig. 4 The first unsupported walking attempts with all four prostheses represent a new challenge.*

electric wheelchair on loan, which allowed him to move around the facility independently. A prosthesis has not yet been fitted due to open wounds. The abdomen, thighs and forearms showed red, firm and protruding scar tissue as the body's reaction to the infected shoulder. Bacteria was present in the surgical wound on the right thigh.

Of particular note is the patient's mental stability at this stage. He always looked ahead, never struggled with his fate and was prepared to push himself to his limits every day. Therefore it was not difficult to set functional goals and to move closer to them step-by-step with all the means at our disposal.

## Goals and measures

The goals and measures include:

- Promote wound healing with $CO_2$ bath, lymphatic drainage, massage
- Achieve a good residual limb shape by wrapping the arm and leg residual limbs
- Maintain mobility and strength in all joints through physiotherapy in all basic positions
- Improve shoulder mobility through manual therapy and a mobilisation splint
- Build strength in the shoulders, trunk, hips and knees through a brace position in the forearm rollator, PNF (proprioceptive neuromuscular facilitation) and the use of therabands

## Course of treatment

Our focus was on mobilising the right shoulder joint and building up strength in all extremities and the trunk in preparation for standing, walking with prosthetic legs and using prosthetic arms. All joints had unrestricted movement except for the right shoulder. The patient has always liked laying on his stomach. This was a good prerequisite for maintaining spinal mobility and hip extension for the ability to stand with leg prostheses later on.

Through intensive training, the patient was soon able to support himself in a high rollator with hanging legs. The simultaneous abduction and extension of one leg in order to place it on the back of the bench demanded a high level of effort from him. Abdominal muscle training and leg strength training while lying down were part of the daily programme and independent training. Our physiotherapy sessions also included stretching the back of the body in a long sitting or supine position.

Thanks to the rapid fitting with lower limp prostheses by O&P, the patient was able to make his first attempts at standing and walking in a high rollator after just a few weeks. We went walking at least once or twice a day. After two weeks, forearm crutches replaced the high rollator. From this point on the patient was able to walk between two benches. He was courageous and fit enough with regard to his balance to temporarily go without the crutches. On good days he managed about 100 metres with brief standing breaks. Wearing the arm prostheses while walking posed a new challenge (Fig. 4).

## Outlook

In future, the patient will be able to move around either with an electronic wheelchair or even walking unsupported. This means he will be able to take care of himself and probably return to work. He has lots of ideas and enough energy to realize his dreams in life.

# Occupational therapy

*Stefanie Bosch*

At the beginning of the occupational therapy process, we clarified with the client which activities are important to him that he would like to soon be able to carry out independently again and which long-term goals are relevant to him.

In addition to defining goals, it is of central importance to assess the client's current status in terms of participation, activity and function. The main focus was on his right shoulder joint, which showed an active range of motion of less than 60 degrees in flexion and abduction after surgery. In addition to the multiple amputation, this also limited his independence in everyday life.

At the beginning of rehabilitation, the client learned to use his residual forearm limbs for routine activities, such as washing and dressing. He clasped objects between both residual

forearm limbs or transported them on the residual limbs. He also held objects with his teeth, such as a tube of toothpaste, in order to open the screw cap with the residual limbs. In addition, customised aids such as cutlery cuffs facilitated the client's independence in everyday life (Fig. 5a). We also prepared the patient for wearing the myoelectric prostheses. The weight of a hand prosthesis is approx. 500 grams plus the weight of the socket, which is why the muscles atrophied by the amputation had to be trained.

Initially, the prosthesis training included the safe and repetitive initialization of the various grasping movements. We then practised these using everyday objects. In doing so, it was important to integrate objects into the training that differed in size, weight and stability (Fig. 5b and c). This allowed us to try out different grips, whereby he adjusted the gripping force to the respective objects.

## Course of therapy

During the course of treatment, we regularly reviewed with the user which therapy goals had already been achieved and which had not yet been achieved. We also discussed whether objectives have changed in terms of content or timing. Based on this and taking into account the physical status of the right shoulder, we adapted the treatment procedures and used aids to adjust the training accordingly.

We then expanded the everyday training with the prosthetic hands to include practising household activities with bilateral movement (Fig. 5d). Food handling and the preparation of simple meals were some of the many different tasks that we tested and practised with the client. As he uses a computer for his job, we practised using the keyboard and mouse with the prosthetic hands. This revealed that the prosthetic hands were too large to operate a standard mouse and that appropriate accommodations had to be made at the workplace. This illustrated that trying out as many different

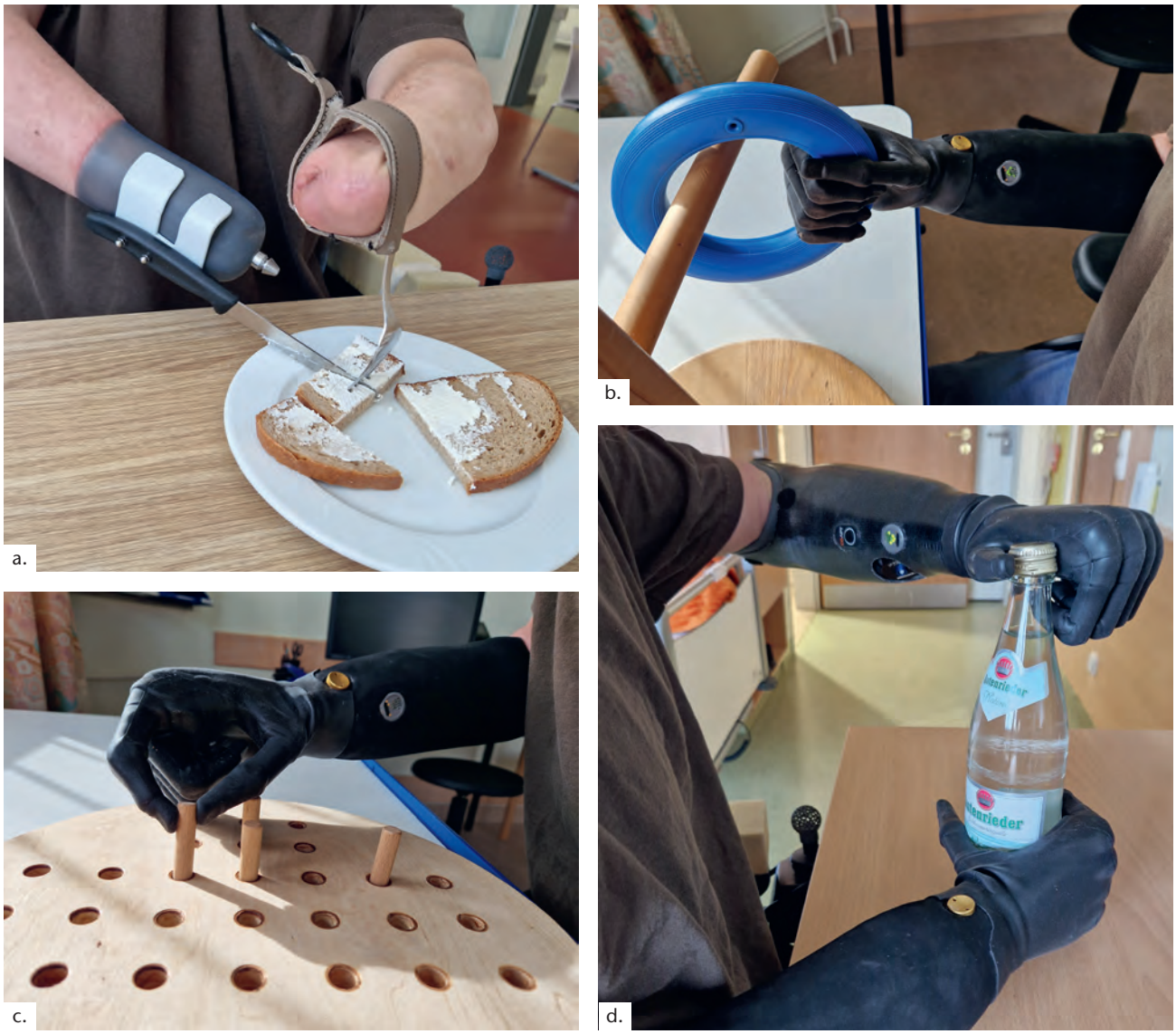


***Fig. 5a–d*** *The knife is securely attached and, in combination with a cuff for the fork, independent eating is made possible* ***(a)****. Targeted grasping and releasing provides experience in controlling the prosthesis and its components* ***(b)****. By using objects of different sizes and shapes, prosthesis wearers train various grips and the controlled use of force* ***(c)****. Bilateral ADL training enables the use of prostheses in everyday situations* ***(d)****.*

activities as possible raises clients' and practitioners' awareness of other challenges that multiple amputees face in everyday life.

## Outlook

By the time of discharged to his home, the patient was independent in many daily activities related to personal hygiene and dressing. His goal of being dependent on as few aids as possible will be pursued in further outpatient therapy.

In order to meet the challenging treatment of multiple-amputees on equal terms, several aspects must be taken into account. In addition to the close interdisciplinary exchange, however, the client is more than ever at the centre of treatment and takes on an expert role for himself. Therapists become co-treatment providers who support clients with their expertise in implementing and achieving their goals.

## Conclusion

Close interdisciplinary cooperation is essential in the treatment of multiple amputations. Adequate medical treatment with individual pain therapy, occupational therapy and physiotherapy as well as prosthetic care are important components of the rehabilitation process. Social and family support for those affected plays an important role. Both the patient and their family members should be intensively involved in the entire treatment process at an early stage. Rehabilitation of such complex injury patterns is therefore only possible in suitable specialist departments and usually takes several months.

***Initial publication***

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Peer-Review

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# What is HowToTreat?

"HowToTreat" is the international special edition for professional prosthetists and orthotists exclusively for the world congresses "OTWorld" and "ISPO World Congress". The "HowToTreat" magazine is a special issue with articles specifically for O&P professionals. The special edition will be published at the World Congresses of ISPO International and OTWorld – in close partnership with the organising associations.

## "HowToTreat" is supported by the following organisations:

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Orthopädie.Technik Bundesinnungsverband

The German Association of Orthopaedic Technology represents more than 2.500 orthopaedic workshops with around 40.000 employees. Each year, the affiliated companies supply more than 20 million patients with aids. Thus, the association represents service providers throughout Germany who permanently treat their patients with the highest standards, driving innovation in the German healthcare market.
→ www.biv-ot.org

*International Society for Prosthetics and Orthotics (ISPO)*

ISPO INTERNATIONAL SOCIETY FOR PROSTHETICS AND ORTHOTICS

ISPO is a multidisciplinary organisation that promotes access to appropriate and equitable rehabilitation, mobility devices, and other assistive technology to improve the quality of life for people with reduced mobility. Prosthetics and orthotics services enable people with limb amputations or physical impairments of their limbs or spine to achieve greater function and independence to participate in society. Alarmingly, according to the World Health Organization, such services are not available to an estimated 9 out of 10 people with disabilities globally due to a shortage of personnel, service units and health rehabilitation infrastructures. To address this, ISPO has worked to develop the prosthetics and orthotics sector worldwide since its inception in the 1970s. As a global, multidisciplinary, non-governmental organisation aiming to improve the quality of life for persons who may benefit from prosthetic, orthotic, mobility and assistive devices, ISPO provides an effective platform for the exchange and communication on all aspects of the science, practice, and education associated with the provision of prosthetic and orthotic care, rehabilitation engineering, and related areas. ISPO has approximately 3.500 members from different professional disciplines in over 100 countries: prosthetists and orthotists, prosthetic and orthotic (P&O) technicians, orthopaedic surgeons, rehabilitation doctors, physiotherapists, occupational therapists, orthopaedic shoemakers, nurses and biomechanical/rehabilitation engineers.
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