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POSSIBILITIES OF INFLUENCING THE POSTURE AND LOCOMOTION BY AFO ORTHOSIS WHILE SUFFERING FROM SPINA BIFIDA

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Abstract: The work is focused on the possibility of influencing pathological standing and walking, using AFO orthoses while being disabled in the lower limbs with spina bifida, in other words, suffer from spine cleft. To influence the posture and locomotion of the patient with spina bifida - myelomeningocele, the application of AFO Carbon Ankle Seven was chosen [1]. The patient's muscle groups controlling the foot were significantly weakened, the knees were in a varus position. While standing, distinct hyperlordosis was visible and, at the same time, a slight bending of the torso as a result of balancing compensation was obvious. The main purpose of orthosis use is to improve the stability, balance, movement and walking dynamics of the patient.

1 Functional principles of selected AFO

The AFO orthosis (Figure 1) is an externally applied orthotic device in the area of the ankle joint and foot. It compensates the weakness and instability in the area of the ankle joint. It is designed to control the position and movement of the ankle, which means that it controls the ankle directly, but it can also be designed to control the joint indirectly. AFO can be used as a part of the footwear or as a full-contact, and it can be used either in static or dynamic design. AFO orthosis with a special carbon spring Carbon Ankle Seven is produced individually and is indicated for very active patients. Thanks to the special design, energy is accumulated in the carbon spring at heel strike and returned at toe-off. The orthosis allows the patient to walk naturally with lower energy usage [1,2].

The construction of the carbon spring takes into account the natural external rotation of the foot - 7°, while taking the dorsal arrangement into consideration. The proper manufacture of the plaster model and also precise construction of the actual orthosis usually means that the physiological posture of the patient's foot is preserved during walking. External rotation of the carbon springs in the area of the bend can help by a more favourable course of the foot (Figure 2). The compromise point is a point located in the ankle area that the orthopaedic technician chooses as an auxiliary point while making the orthosis [3].

Figure 1 AFO orthosis, carbon spring and insertion into thermoplastic sleeve

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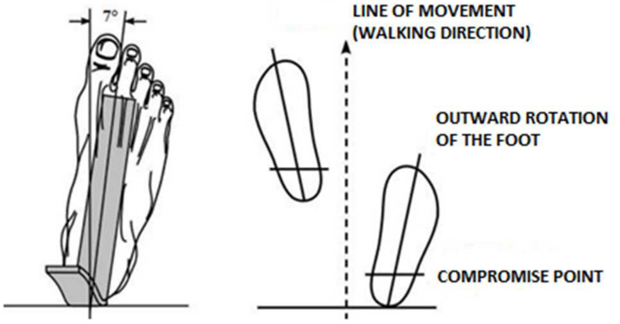

Figure 2 Effect of 7 ° outward rotation of the spring on the walk [2]

Choosing the right strength of the carbon spring is performed according to the body weight and the degree of user activity (normal or high level of activity). It is a prerequisite that the patients be able to walk. For active orthosis users, who use to walk or run more often, the demands and requirements on the spring strength increase. Application of Carbon Ankle Seven leads to a positive effect on the image of walking with support of the front foot, as shown in (Figure 3) and dynamic knee joint effect (Figure 4).

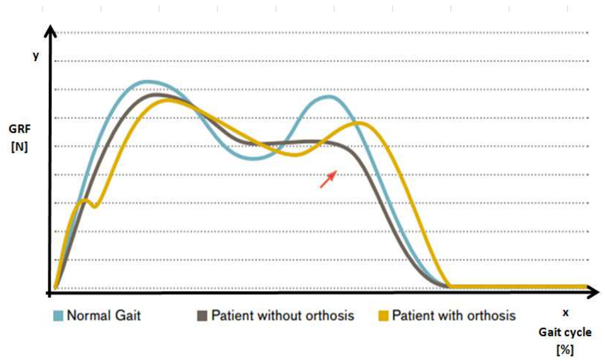

Figure 3 Comparison of the course of the ground reaction force from the pad under physiological conditions, in the pathology without the use of the orthosis and with the compensation achieved by the AFO [2]

By using AFO, the positive effect is evident. In the foot area, the results such as the energy return effect, support of the forefoot to the tip of the toe, harmonization with natural walking, and dynamic dorsal and plantar limitation of carbon fibers that support smooth walking, are achieved [3].

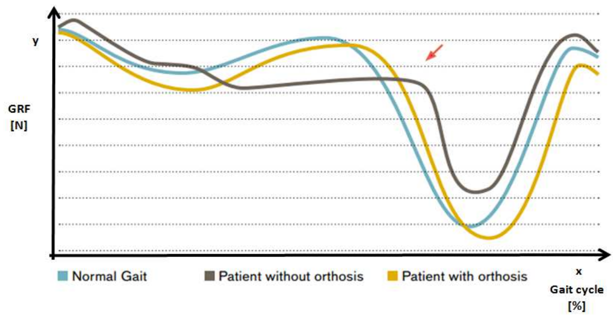

Figure 4 Illustration of increased knee dynamics when walking with AFO[2]

Also, by using AFO, an increase in knee joint dynamics is achieved. That leads to positive effect on the body's uplift with the extension of the hip and knee during the standing phase, more stability in the knee joint, and also the image of a walking resembles the physiological walking more [3].

2 Production of Carbon Ankle Seven

Physical examination consists of control, palpation, tapping - to find reflexes, and also includes a functional muscle test. The medical check-up of the patient consists of examination and observation of patient's reflexes and conditions. Palpation consists of examining sensitive bone structures, wrong leg postures, scars and wounds, which must be included in making the orthosis. After all the examinations, the measurements take place. All necessary measurements, such as length parameters, circumference of the limbs, as well as other important information and results, are written down into specific measurement forms. If necessary, also other details are marked down. On the lower limb, the measurements are taken on lower leg and foot.

To make a plaster negative, we need a container of water, plaster bandages, the carbon spring itself (or its template), nylon stocking for easier removal of the plaster negative from the patient's body, scissors, pencil, separation vaseline and a plastic tube. Also a pad under the foot with height adjustable heel, alternatively with a correctional heel and the front wedge to ensure the dorsiflexion positioning of the toes in the forefoot is very important. For better positioning of the carbon spring under the foot, it is necessary to slightly increase the heel by approx. 15-20 mm before making a plaster negative. On the limb, the compromise centre of rotation is marked in the ankle joint, as well as all protuberances, bone protrusions, pressure sores and painful places. It is also possible to mark the areas that need to be pressurized or relieved, as well as marginal lines.

First, a footprint is made. That means that a thorough footprint with a transversely and longitudinally shaped foot surface and its arches in the neutral position - sagittal plane – is created. The limb is separated by a nylon stocking and only then a print of shank is made. The footprint part is then attached with plaster bandage to the foot and shank plastering follows. Under the plaster bandage, there is a separating device, usually a tube, inserted, so that the print can be removed from the limb after hardening. The foot part should be kept in the correct position in the frontal and also in sagittal plane until hardening (Figure 5).

Figure 5 Plastering of foot and shank

After hardening, the guide lines are market transversely to the center axis, so that the precise reconnection of the cut plaster negative can be achieved. The print is cut and the bandage is removed. By this way, the plaster negative is made; however, it still needs to be checked for the correctness of the design. A suitable metal tube is inserted into the model. The outer end of the tube is used to attach the model itself into a gripper. Before molding, it is necessary to close holes using plaster bandages, so that the plaster cannot leak out. After checking the orthosis position in adjusting apparatus, the liquid plaster is poured onto the negative and is left to solidify. After hardening of plaster, the negative is removed from the stand, by pulling off the bandages and the positive model is selected, Fig.6. The model is then adjusted, so that to areas that need to be relieved, another coat of plaster is applied and from areas that need pressurization the amount of plaster is lowered. The deflections are evened and the model is smoothened at the end.

Figure 6 Positioning of the carbon spring on the plaster positive

The length of the calf is marked. The end of the carbon spring goes 20 mm under the cut in the heel area joint. The position of the carbon spring under the foot is marked. The length of it is from the heel to approximately 20 mm under the cut in the heel area joint. To mark the area of fixation and movement of the carbon spring, the model is divided into two parts. First, the length from the knee slot to the ground is measured and then the half of this measure is marked. To adjust the carbon spring to the actual shape of the shin, the lining from Pedilin needs to be applied and grinded onto particular areas, and if necessary, also the areas with possible cavities have to be filled. Due to external rotation, and when positioned correctly, the carbon spring flows in the area under the foot in the way of second metatarsal bone. Afterwards, the carbon spring is fixed to the model by a polyethylene duct tape across the foot arc and under the calf (Figure 7).

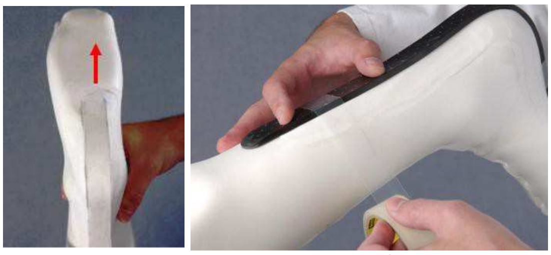

Figure 7 Check the correct positioning of the spring and its fixation to the positive

Then, one coat of perlon jersey is stretched onto the model. It is necessary to mould the high temperature thermoplastic on the model, using the negative air pressure. After the thermoplastic is shaped, the course of cutting edges is marked and the plastic is taken off the plaster positive model. In the foot area the cutting edge is above the ankle and in the calf are approximately to the middle of the calf. It is important that the cutting edges are not sharp; therefore they need to be grinded. At last, the calf area is separated from the foot area (Figure 8).

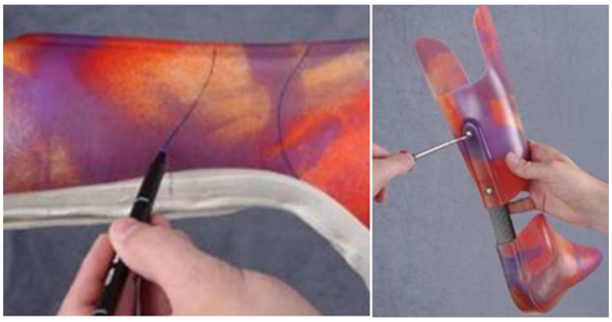

Figure 8 Marking of cut edges separating the foot and calf part and final assembly of the orthosis

Then the places for drilling holes in the calf area are marked. It is important to drill holes for carbon spring in the middle, because otherwise the premature wear out or carbon spring crack in the area of drilling can be inevitable. Also in the foot area the places for drilling holes are marked. The proximal hole is not at the highest heel point, because the carbon spring bends there.

3 AFO trial and application

To check the sagittal structure, the trial with the orthosis applied while using the laser vertical line, is

recommended. On the lower limb, the load line should flow 15 mm anterior from the compromise point of knee joint according to Nietert, who characterized the middle point of rotation. It is a posture in which the axis of orthosis knee joint rotation should be placed. It is the most neutral point in relation to natural polycentric knee joint and is determined empirically – in the anterio-posterior way: 60 % from the front and 40 % from the back, 2 centimetres above the medial slit of condyles.
The load line flows 2 mm posterior from large femur (trochanter), 15 mm anterior from the centre of the knee according to Nietert, 60 mm anterior from the outer ankle (Figure 9).

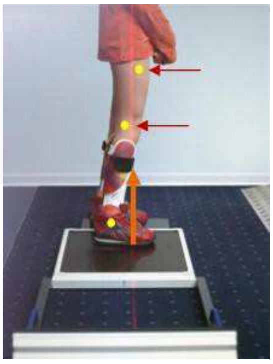

Figure 9 The correct course of the load line in the sagittal plane

Conclusions

At the examined diagnosis, the correct function of muscles controlling the foot was necessary to support. The muscle work was replaced by an "L" shaped flexible component made from composite material that was used as a basic material of the whole orthosis. The spring was embedded into the high temperature thermoplastic sleeves. The finished orthosis was completed by Velcro taping and the lower part of the foot area was evened as necessary.
By applying the AFO the stable upright stand of the patient was achieved. The stand corresponded with optimal load lines and it resulted in more stable as well as dynamic walking (Figure 10). Recently, the patient is able to walk along uneven terrain, stairs, as well as to ride a bike.

Figure 10 Stand before and after AFO application

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