Technically controlling joint angles while making a negative cast as basis of functional orthoses for patients with neurological gait disorders

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Background and Aim

Custom-made orthoses contribute to gait rehabilitation of patients with neurological gait disorders. Yet, a successful orthotic fitting is bound to certain conditions. As a consequence, a correctly adjusted dorsiflexion stop ensures a knee extension moment by triggering the forefoot lever in terminal stance [1] and enables activation of the knee joint. For example, the exact locking and unlocking of a stance phase controlled orthosis crucially depends on correct joint angles. The individual normal posture each patient is positioned in while casting determines the joint angles and should hence be planned and performed thoroughly [2].
Considering this, an innovative tool is introduced which enables transferring the patient's individual normal posture to the negative cast.

Materials and Methods

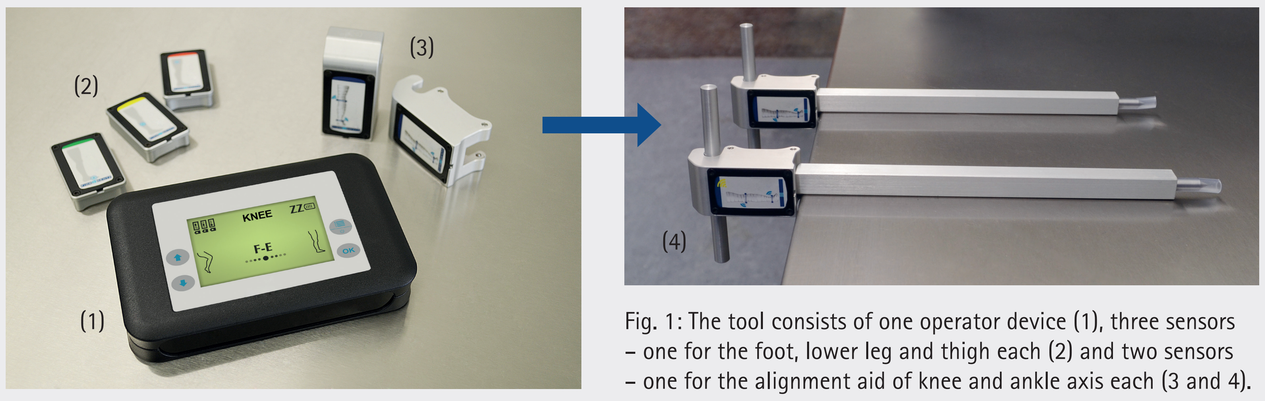

Fig. 1: The tool consists of one operator device (1), three sensors – one for the foot, lower leg and thigh each (2) and two sensors – one for the alignment aid of knee and ankle axis each (3 and 4).

A device with five sensors was tested (fig. 1). Each sensor detects its spatial coordinates and communicates with the operator device via Bluetooth. At this point, the absolute position of each sensor, the relative positions of two sensors to each other and therefore the joint angles are being calculated. This calculation's accuracy is within <1°.

Results

The three sensors are attached to thigh, lower leg and foot. In order to take last pitch and a potential leg length compensation into account, the patient is positioned in his individual normal posture on a heel height/leg length compensation tool (HLCT) under consideration of the lateral rotation of the foot. The present angles are saved with the operator device (fig. 2). In the next step foot, ankle and lower leg are casted while the sensors remain attached to the patient's leg. Before the cast has hardened, foot and lower leg are put into the saved sagittal and frontal positions being positioned on the HLCT again. The operator device indicates when that position is reached (fig. 3). This procedure is repeated for casting knee and thigh (fig. 4). As soon as the negative cast has hardened it can be taken off together with the sensors.

For a correct orientation of knee and ankle axis the lateral rotation of the foot has to be considered. Therefore the two sensors have to be mounted on the alignment aids before making the positive cast (fig. 5).

Discussion and Conclusion

With the digital casting aid, joint angles of sagittal and frontal plane can be transferred to the negative cast. Casting technique is optimised by reproducing joint angles of the individual normal posture with maximum precision. Proceeding as described before, activation of the mechanical knee joints and the effects of a dorsiflexion stop can be quite improved. Further measurements need to be done.

Keywords: Orthotics, neurological gait disorders, negative cast, joint angles, digital casting aid, stance phase controlled orthosis

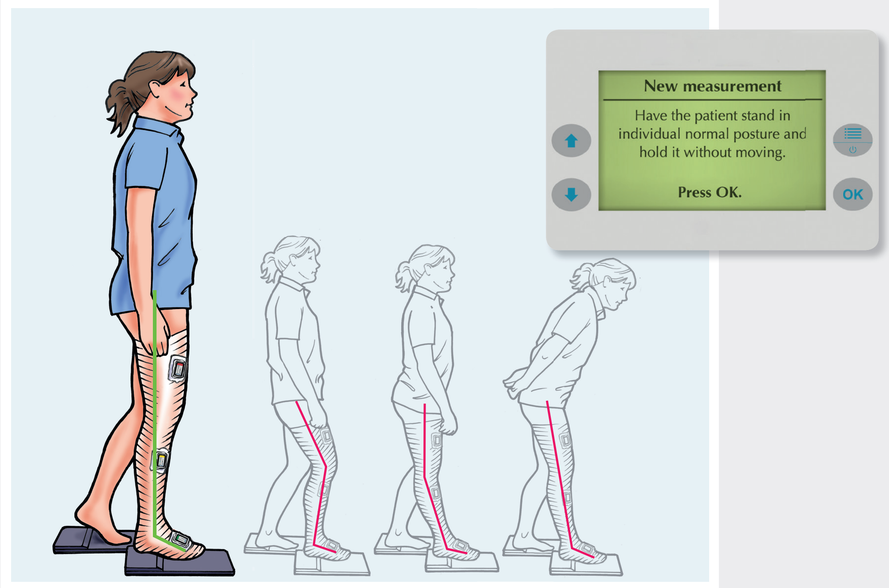

Fig. 2: Positioning the patient on a heel height/leg length compensation tool (HLCT) in his individual normal posture after placing sensors on thigh (red), lower leg (yellow) and foot (green).

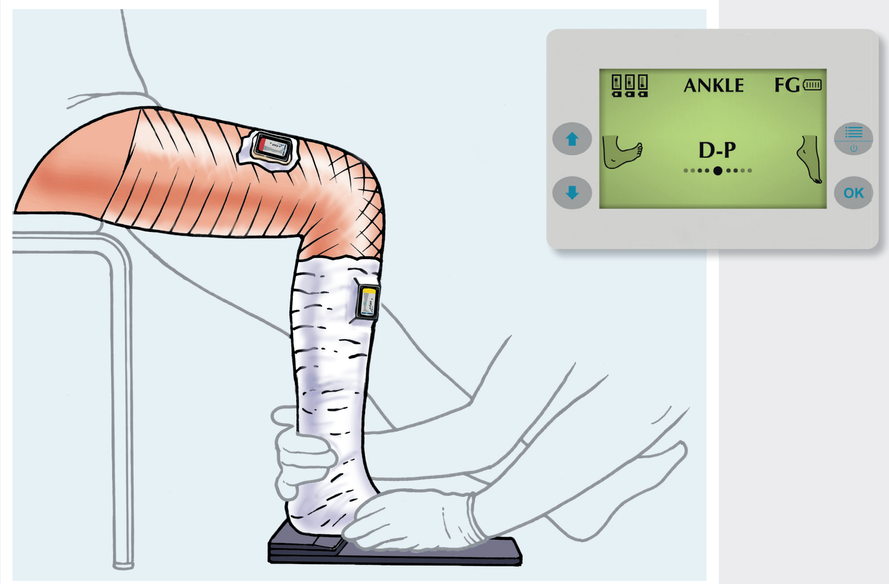

Fig. 3: Casting of foot and lower leg. Before the cast has hardened, place the foot on the HLCT and restore the ankle angles shown on the operator device.

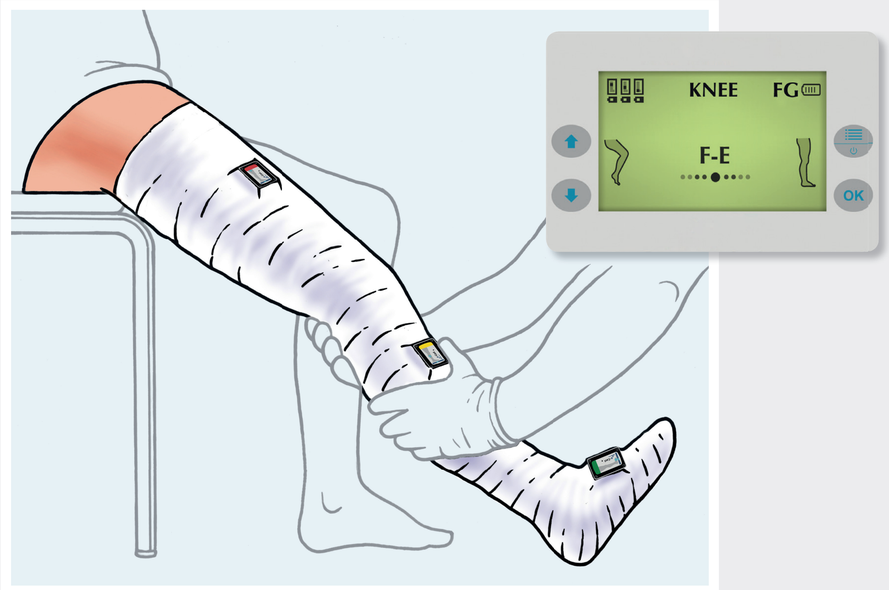

Fig. 4: Casting of knee and thigh. Before the cast has hardened, restore the knee angles.

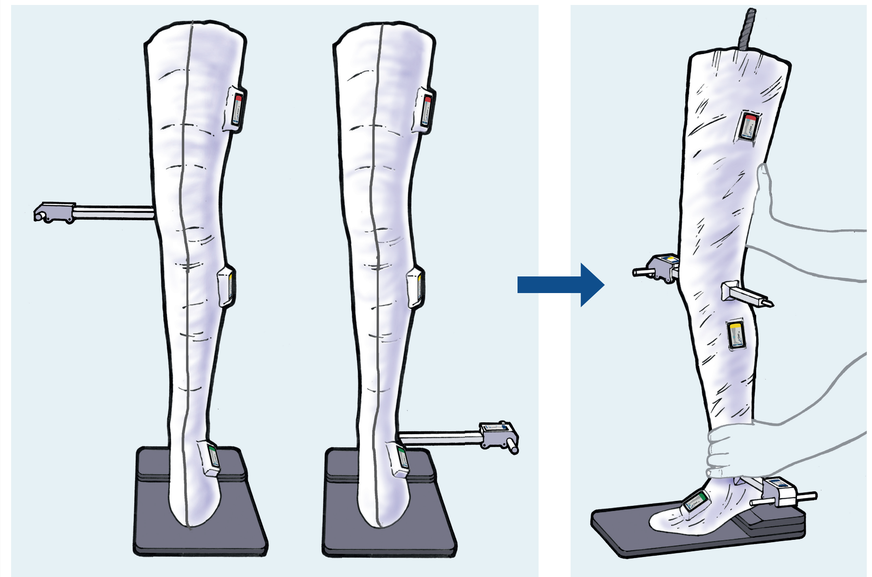

Fig. 5: Placing the alignment aids with sensors at medial knee and lateral ankle pivot points. The operator device displays the correct positions of the alignment aids. In these positions the alignment aids should pierce the lateral (knee) and medial (ankle) side of the negative cast. When all five sensors are properly placed, the positive cast can be made.

Literature

[1] Sabbagh D et al. About the necessity of a dorsal stop in KAFOs for patients with paralyses and weak plantar flexors. 15th ISPO, 2015.

[2] Dünnwald A et al. Factors influencing the joint angles of lower extremities from an orthotic perspective. Orthop Tech 2015; 66(3): 42-46.

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