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Individual Engineering-Orthopedic Care for Patients Suffering From Infantile Cerebral Palsy[1]

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A special consulting hour for patients was set up within the scope of collaboration between the Orthopedic Clinic of the University of Mainz and the Children's Neurological Center of the state of Rhineland-Palatinate. Emphasis is placed on conservative care of children suffering from cerebral and behavioral disorders.

The purpose of engineering-orthopedics in this case is to modify proven designs to meet particular individual needs and to apply new techniques in dealing with the multi-faceted problems presented.

It must be understood that, basically, the cerebral-palsy child is a brain-damaged child. The damage is in the first central motor neuron, the disorder affecting predominantly the control mechanisms of motion. The resultant neuromuscular malfunctioning takes the form of various pathological symptoms, but provides only a partial indication of the overall damage; or ought to be considered as such. Roughly speaking, a distinction is made between hemiplegia, diplegia, and tetraplegia. Disordered coordination of motion (ataxia) and also involuntary non-controlled motion (Athetosis) are frequently noted in this respect.

Because of these pathologically symptomatic conditions, the patients are predestined for special care involving modern therapeutic gymnastic methods. Correction of neuromuscular dysregulation and improper posture can be achieved in an autonomous manner. Supplementing and functionally improving steps may also be introduced and realized with directed attention-absorbing therapeutic techniques. The work by this pair of professional groups (KG and BT) must be given priority over technical orthopedic measures. A fairly good support of the therapeutic measures is provided by commercially available orthoses. However, the desired goals cannot always be achieved in individual care by using fairly heavy (conventional) orthoses. This is especially the case because fairly heavy appliances, in many instances, enhance the propensity for spasticity because of their rigid, mechanical construction, and because the patient cannot tolerate the loads exerted. The orthoses to be used, therefore, must be so designed that they complement existing residual functions with a modicum of equipment and that they correct pathological dysregulation and improper postures by means of moderate loads of pressure.

They must not hamper existing func-

tions, and simultaneously they must lead to functional improvements by exploiting given static-dynamic conditions.

An earlier report by this author (1) discussed provision of orthoses in dealing with neuromuscular malposture in the region of the upper limbs. The present report extends these considerations to the lower limbs.

The following ought to be the goals in the presence of pathological functioning and malposturing of the lower limb in brain-damaged children:

1. Light to Moderate Dysregulation:
   - compensate for inadequate static attitudes;
   - correction of pathological pattern of motion;
   - suppression of pathological behavior of motion to pave the way to proper movements.
2. Serious and Most Severe Failures and Manifold Handicaps:
   - achievement of standing;
   - provision of devices for correction of existing improper rest positions of the limbs;
   - technical orthopedic measures to ease care and prevention of contractures.

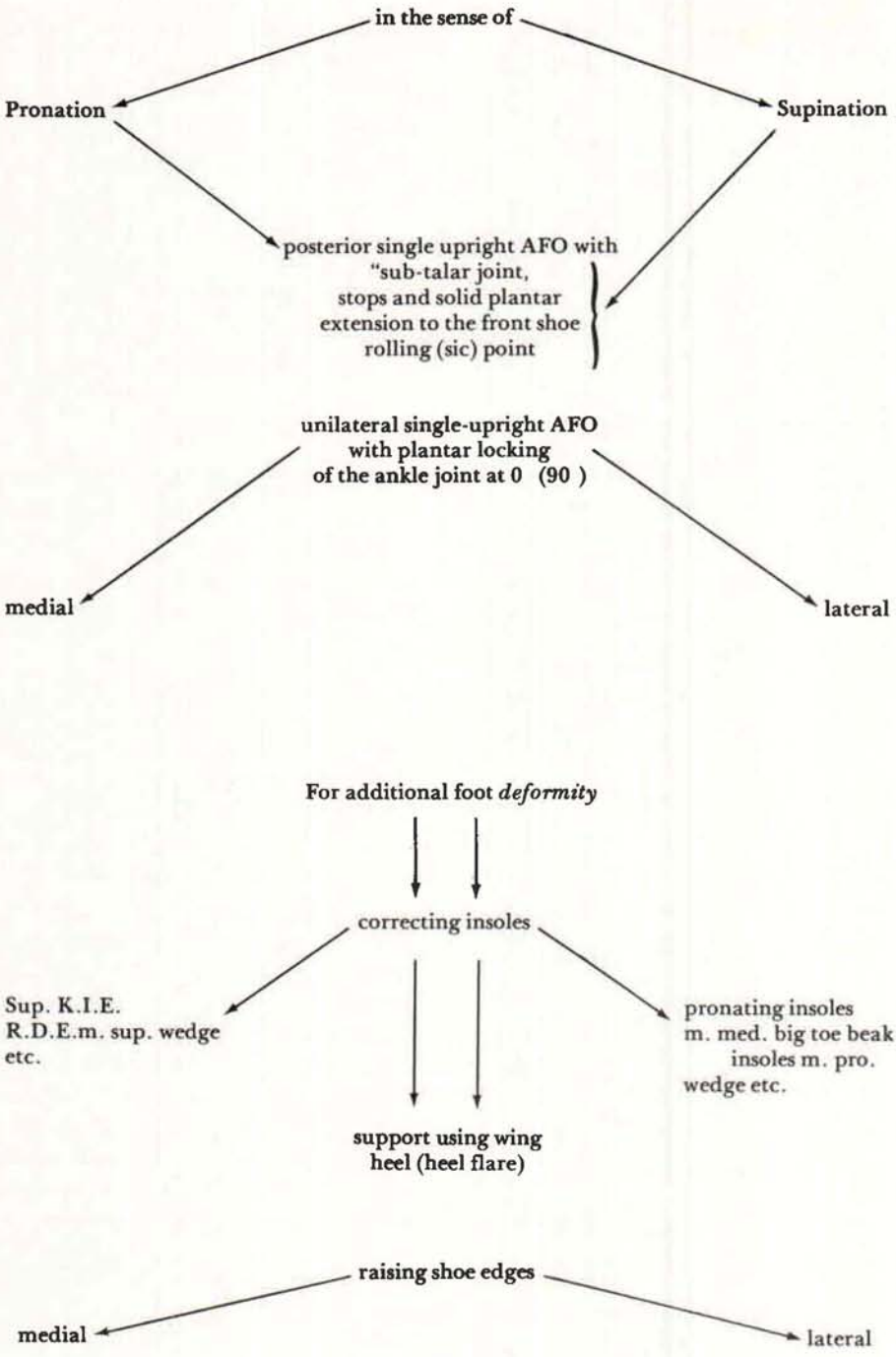
Treatment programs corresponding to these goals were drawn up (Fig. 1) for the most frequent problems found in the

1) Treatment scheme for slight, spastic foot deformities with orthoses
   - 1.1 Defective foot positions with regular arches present.
   - 1.2 Defective foot positions with clearly pathological feet.

2) Treatment scheme for severe defective foot position and foot attitude for the lower limb with orthopedic engineering techniques
   - 2.1 Functional defective attitude in the sense of easily and well compensated equinus
   - 2.2 Still correctable equinus in combination with defective foot attitude
   - 2.3 Difficult-to-correct equinus with marked foot deformity and defective attitude to the lower limb
   - 2.4 Mild calcaneous, dorsiflexion
   - 2.5 Calcaneous with severe foot deformity and defective lower-extremity attitude.

3) Treatment scheme for spastic foot defective position, attitude and rotational aberrations of the lower limb using orthopedic engineering techniques.
   - 3.1 Slight rotational deviations
   - 3.2 Rotational deviation with foot deformity
   - 3.3 Rotational deviation with severe foot deformity and defective attitude of the lower limb

Fig. 1. Treatment scheme for lower-limb for spastic foot deformities.



SUPPLEMENT: functional straps for knee-hip stretching assistance

Fig. 2. Excerpt from the treatment scheme for the still-to-be compensated equine foot.

lower limbs. In conformity with the dysfunctions listed, the individually required technical-orthopedic procedures can then be applied in a rational manner, as shown by the diagram of Figure 2.

Whereas slightly pathological foot positions can be well corrected by means of shoe accessories or special insoles, it is the functional equine foot with flexion contractures of the knee and hip joints which is the greatest problem. The forefoot lever can be extended as shown in Figure 3 so that the body weight automatically corrects the pointed foot by applying a slight pressure so that, in turn, the lower limb straightens.

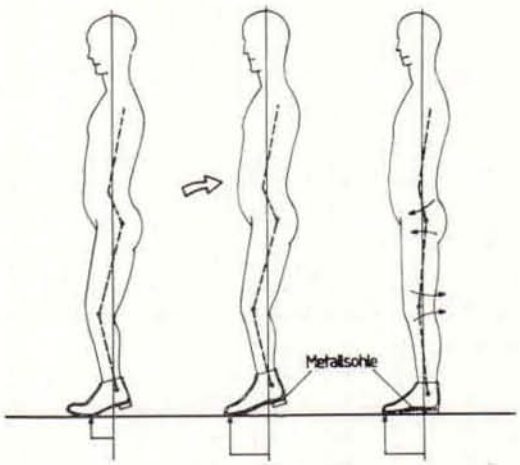


Fig. 3. Statically determined body-straightening.

As regards the spastic equine foot without foot pathology, the body resting-point can be moved forward (Fig. 3) and thus the forefoot lever can be extended in a problem-free manner by means of a simple metal insole in the shoe and by corresponding pads proximal and posterior to the calcaneous, with an additional shoe-tongue cushion (Fig. 4). The purpose of the latter is to fix the foot in the shoe.

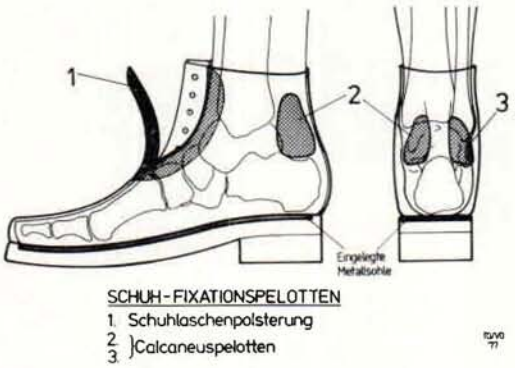


Fig. 4. Schematic of metal insoles arrangement of fixing pads.

Treating the equine foot when appreciable supination is present (frequently seen in hemiplegia) (Fig. 5) is substantially more difficult.

In this case it is found that supination can be quite well corrected by providing a pivoting posterior single-upright AFO with adjustable "subtalar" joint, whereby also the equine foot is very well corrected. As seen in Figure 6, the prosthetic bar first assumes the function of correcting the supination by pivoting the foot into the lower-leg axis, the foot being brought into the right-angle position to the lower leg in the second stage by a back-swing of the dorsal lower-leg brace part (Fig. 7). A lateral projection of the rail fastening mechanism passes in plantar manner to the base articulation of the little toes and thereby prevents the elasticity of the shoe from following the wrong positional tendency of the foot (Fig. 8). This technique makes it possible without the use of expensive equipment to achieve foot-position correction which contributes extensively to sure-footed standing and walking of the patient (Fig. 9).

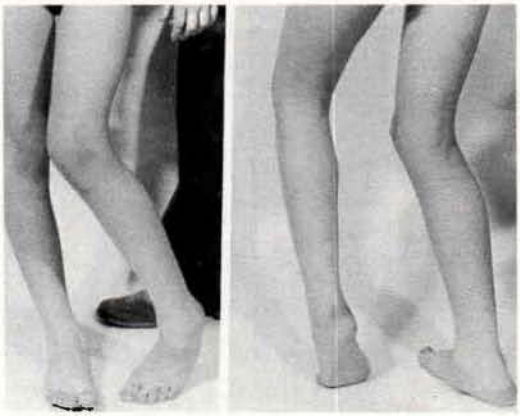


Fig. 5. Patient with left-side plastic hemiplegia in typical attitude.

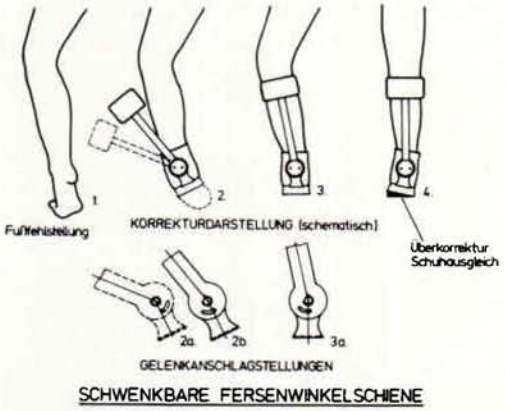


Fig. 6. Diagram of posterior single upright ankle-foot orthosis with adjustable "sub-talar" joint for correcting supinated foot. Posterior view.

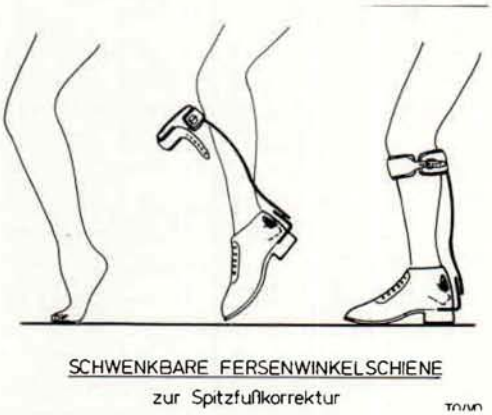


Fig. 7. Lateral view of posterior single upright orthosis with "subtalar" joint showing correction of plantar-flexion contracture.

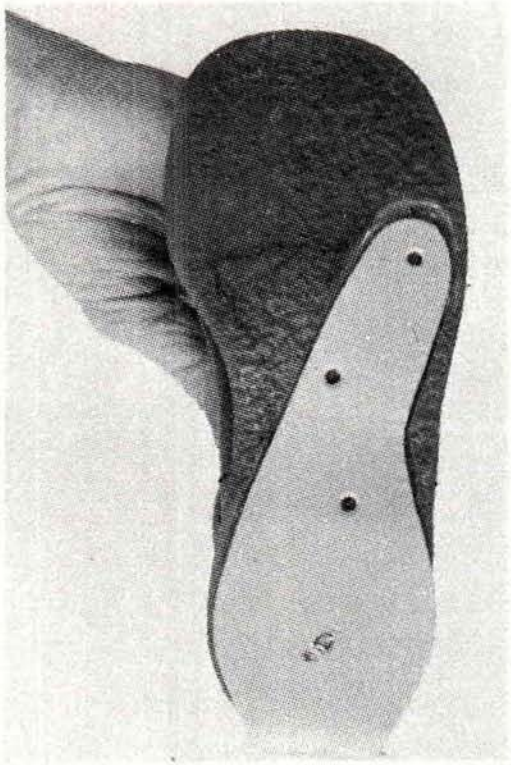


Fig. 8. Plantar view of shoe attachment bar and shoe showing lateral extension.

The spastic equine foot in combination with severe deformity in the sense of the extensively contracting buckled flat foot (valgus), as well as the varus foot in sickle form, can be well corrected by means of a shoe insert and a lateral single upright orthosis (GOCHT's inside and outside lever brace). The corrective forces which are provided can be distributed over a larger, optimally shaped surface so as to be very easily tolerated by the patient (Fig. 10). The advantage of the single bar orthosis in this sort of treatment is that the foot can be brought gradually into the optimal corrective position in successive stages.

The movable and partly blocked ankle joint permits all the activities which oppose the deformity, and these accessories therefore entail only a limited inactivation opposing the pathology. The long

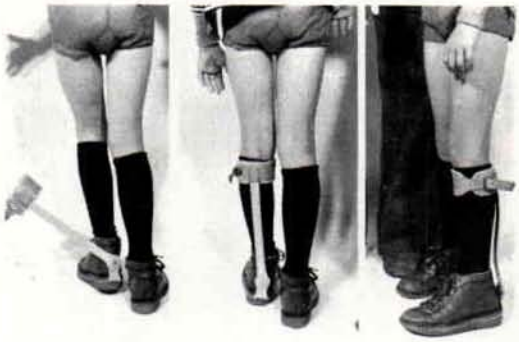


Fig. 9. Patients with posterior single upright AFO with "sub-talar" joint.

Fig. 10. Patient with appreciably spastic valgus flat feet
a) without orthosis
b) straightening by a Gochy inside lever brace with walking shoe (medial single upright AFO with shoe insert sandal)

metal sole under the shoe insert, the stop in the ankle joint, and the firm front strap below the knee joint are known techniques to offset forward the body's center of gravity and further to provide a mechanically static support to achieve lifting of knee and hip (Fig. 11). This propensity to stretching the knee and hip articulations may be enhanced by using a functional bandage (strap) as shown in Figure 12.

Fig. 11. Same patient following technical orthopedic care with Gocht inside lever braces with medial single upright AFO with shoe insert sandals in ready-made shoes.

Multiply handicapped patients (Fig. 13) can achieve, postsurgically, good ability to stand and walk in the conventional sense by means of individually designed devices that increase their radius of action (Fig. 14).

Technical orthopedic measures for children most severely affected physically and mentally will only be meaningful if correction of posture and prevention of contractures (Fig. 15) are achieved.

disturbed children, technical orthopedic accessories of the most varied kinds are used to prevent pathological behavior patterns. By suppressing such deviant behaviorism, the handicapped child can gain access to treatment in psychology, special pedagogy, and behavioral science. The equipment required to such ends are illustrated by two cases.

The disturbed behavior of the first patient, a female, took the form of permanent onanism. An individually made chastity belt (Fig. 16) interrupted this aberrant behavior and simultaneously

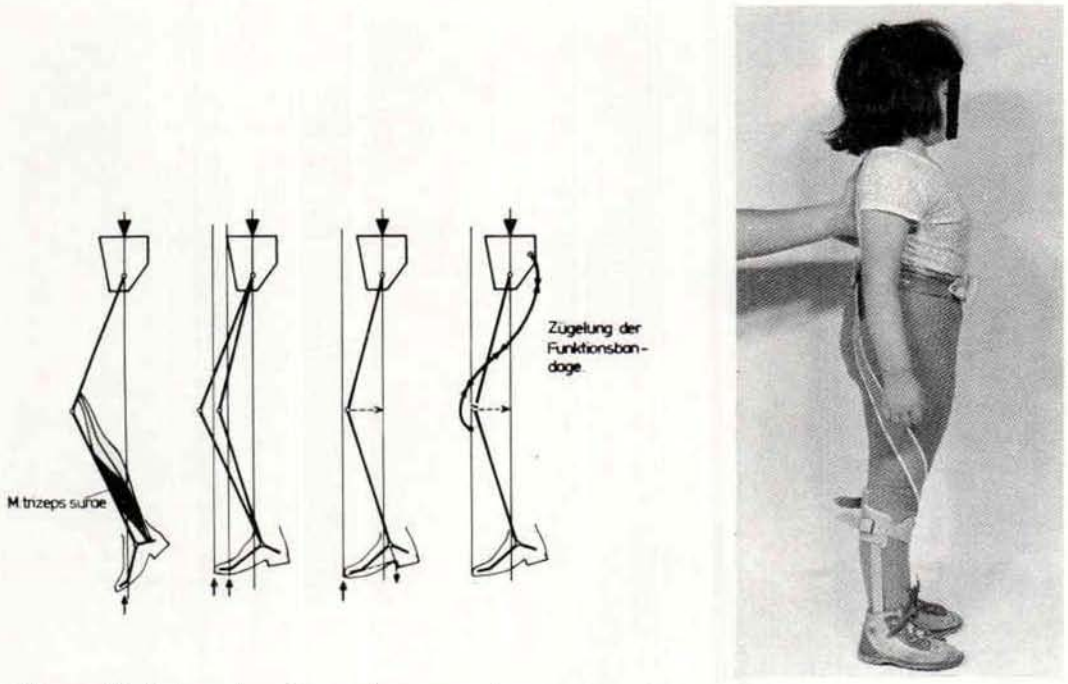


Fig. 12. a and b: Schematic and actual representation of support for knee and hip stretching by functional straps.

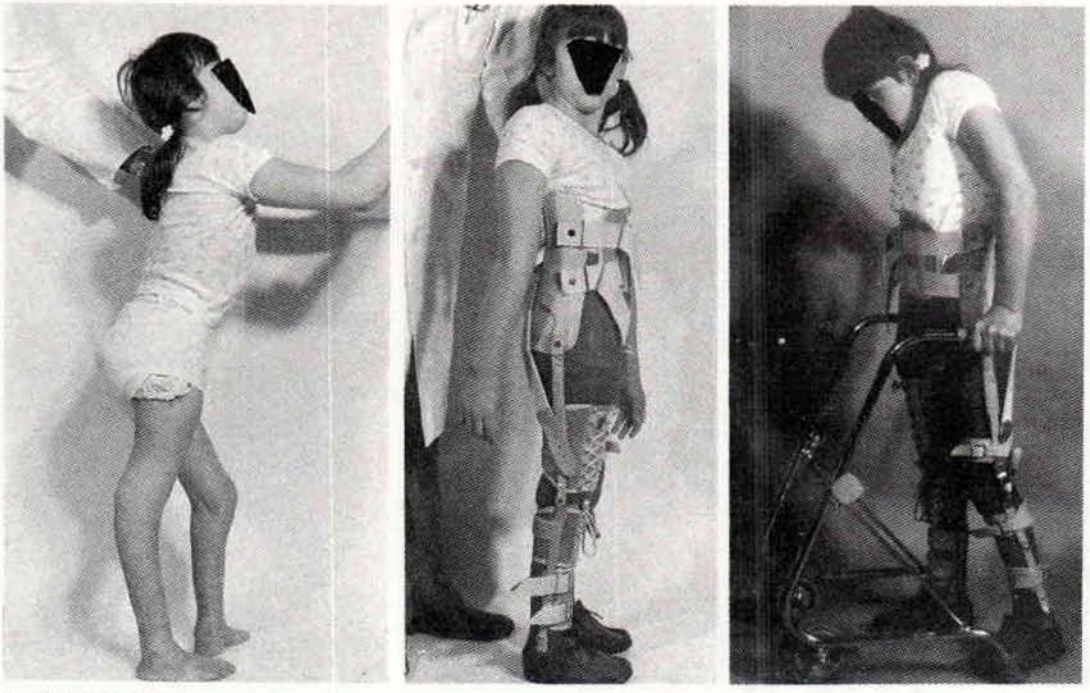


Fig. 13 & 14. Multiply handicapped patient with appreciable restrictions on knee and hip functions. The same patient equipped with engineering orthopedic means.

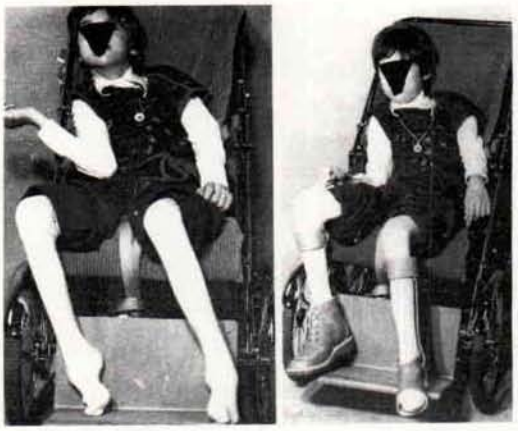


Fig. 15. Patient with defective attitude of lower extremity in wheelchair, without and with correcting means.

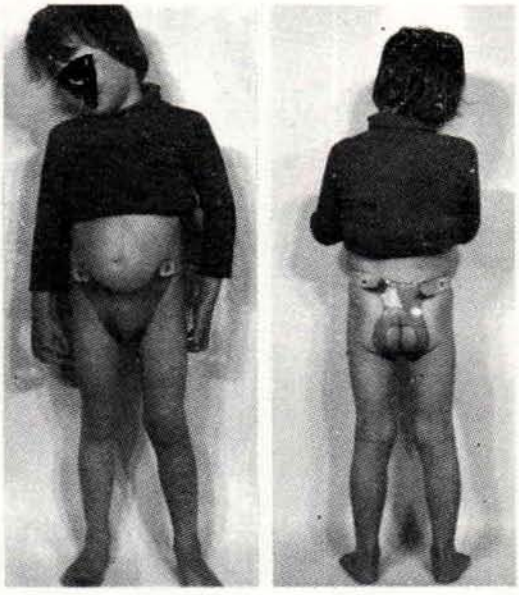


Fig. 16. Female patient with chastity belt in various views.

allowed introduction of specific therapeutic procedures.

Technical orthopedic devices may also be indicated for patients whose aberrant behavior takes the form of self-aggression. Frequently substantial injuries occur, the patients using their own body parts to such ends most of the time. Figure 17 illustrates a boy who first injured his face and head with his hands. After being prevented from doing so, he used his head to abuse his shoulders. To prevent this as well, Plastazote foam devices covering the endangered shoulder

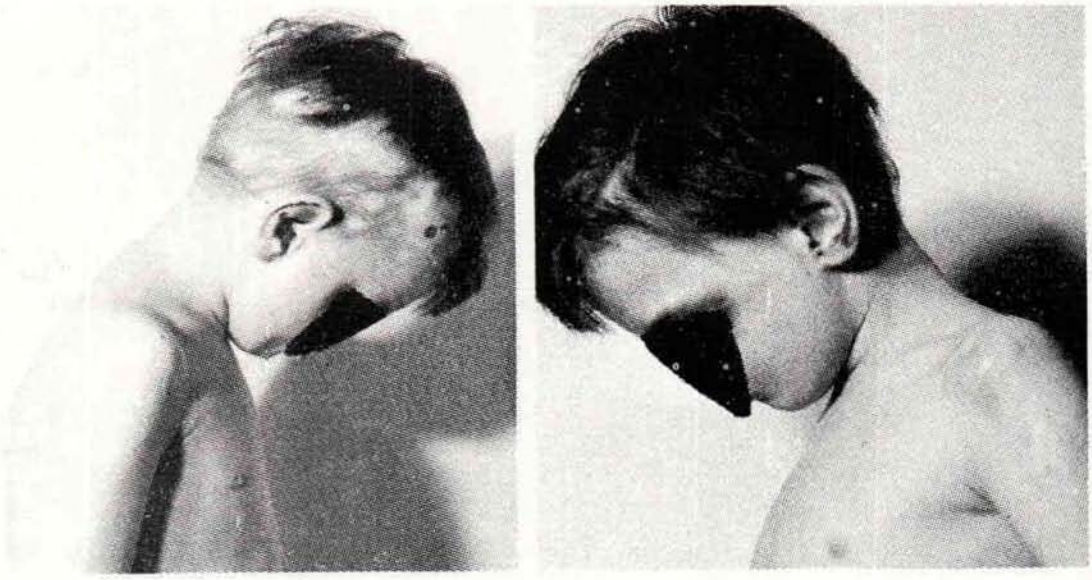


Fig. 17. Injuries of an auto-aggressive patient.

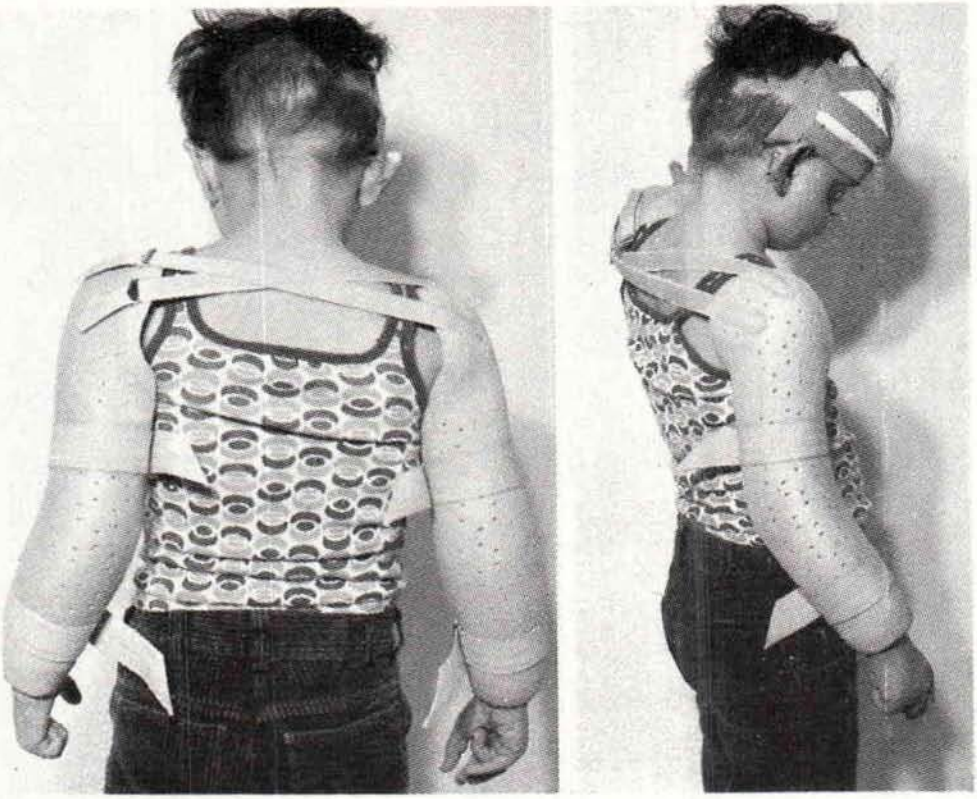


Fig. 18. Technical orthopedics with Plastazote arm splints.

parts were formed and fitted to the patient. The elastic material and the relatively loose back connection (Fig. 18) allows considerable freedom of motion for all sorts of activities without permitting self-injury.

Besides being protected, the patient was also expected to be becalmed so he could be treated with appropriate psychotherapy.

The treatment discussed herein should provide an overview of technical orthopedic measures which have been found practical within the scope of the special care of children suffering from cerebral palsy and behavioral disorders.

In conclusion, I wish to thank here my collaborators for their support, without which the care and treatment described above could not have been implemented.

Literature Cited

(1) R. Volkert and W. Schoen, "Individuelle orthopaedisch-technische Hilfsmittel zur Funktionsverbesserung der behinderten Hand, ORTHOPAEDIE-TECHNIK 29, (1978) 13-16.

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