CASE REPORT

Upper Extremity Casting: Adjunct Treatment for a Child With Cerebral Palsy Hemiplegia

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A common upper extremity deformity with hemiplegia is pronation contracture of the forearm in association with flexion contracture of the elbow. Early management of the child with hemiplegic cerebral palsy is critical in optimizing overall function. The use of inhibitory upper extremity casting can enhance function and improve arm–hand position. The present paper describes the evaluation process before casting, the goals of each phase of the casting program, and the follow-up.

Spasticity is found in almost every child with hemiplegic cerebral palsy and creates a major problem in the provision of care. Spasticity can seriously delay upper extremity motor development and function. Untreated, it results in a persistent flexion pattern in the upper limb with an internally rotated shoulder, flexed elbow, pronated forearm, and flexed wrist and fingers. This position decreases the ability to use the hand and wrist in both supination and pronation (Bobath & Bobath, 1975). The malalignment of the joints and abnormal tone affect the quality and fine motor control needed for prehension and bilateral hand use. Early management of spasticity is therefore critical for the optimization of function.

Management of the child with hemiplegic cerebral palsy requires various treatment techniques and interventions, of which the neurodevelopmental treatment approach is most common. This approach is used to inhibit abnormal movement patterns and facilitate automatic patterns of movement. Gains, however, appear to last for only a short time. As an adjunct to therapy and as a means of getting carryover of achieved gains, I explored the use of upper extremity casting.

Few articles document the use of upper extremity casting in children with cerebral palsy. In one study of 38 pediatric subjects with cerebral palsy with whom plaster casts were used (Groen & Domnissee, 1964), an arm cast extending from above the elbow to the fingertip was applied on only 3 of the subjects. One of these children demonstrated good results, that is, a gain in range of movements; the second child had poor results, and surgical wrist arthrodesis was advised; and the third child withdrew from the study, thereby yielding no outcome. The report did not describe the long-term results of functional control of the impaired limb.

The present case report describes the casting protocol used with a child with hemiplegic cerebral palsy. The goal was to inhibit the abnormal movement pattern while prohibiting the habitual flexor pattern of compensatory stabilizing effort in order to enhance function and improve arm–hand position both during and after casting. A long arm cast was applied to the impaired upper extremity to modify spasticity at the elbow, forearm, and wrist. A short arm cast incorporating the wrist, hand, and thumb was applied to the sound upper extremity. This prevented the use of the sound hand for fine motor skills and encouraged spontaneous use of the impaired arm. The present study emphasizes the initial assessment, occupational therapy intervention, parental involvement in treatment, and outcome of care.

Criteria for Casting

Novel treatment approaches often build upon allied existing protocols. The goals of casting are similar to
those of surgery, and the prerequisites established for successful surgical candidates may be easily applied to casting candidates. Both treatment approaches are designed to improve the function and appearance of the spastic limb. Indeed, early management of the hemiplegic arm may prevent the necessity for surgical correction later in the child’s life. The prerequisites used by orthopedic surgeons for potential surgical cases are described below.

**Voluntary control.** The amount of voluntary motor control at the joints to be casted is an important indicator for casting. Prognosis is best for those children who use the involved arm as a gross functional assist for active reach, weight bearing, bilateral tasks, and grasp and release of objects (House, Gwathmey, & Fidler, 1981; Keats, 1965; Zancolli & Zancolli, 1981).

**Motivation and intelligence.** The child must enjoy moving and exploring the environment. The candidate for casting must exhibit a willingness and ability to cooperate and perform motor activities on command, such as reaching and opening and closing the fingers, because successful casting depends on the child’s ability to cooperate. The child should exhibit no significant behavioral or cognitive problems (House et al., 1981; Keats, 1965; Mital, 1979; Samilson, 1966).

**Realistic parents.** Parents must have a realistic understanding of the casting program and not expect the child’s spasticity to be cured as a result of the program. The parents must be motivated, must actively participate in weekly therapy sessions, and must follow up with a home program (Keats, 1965; Mital, 1979). Realistic parents have the capacity to encourage their child to continually use the casted limb.

**Sensation.** Most children with hemiplegia are believed to have some impairment of stereognosis and proprioception. Severe sensory impairment limits the prognosis for casting (House et al., 1981; Keats, 1965; Zancolli & Zancolli, 1981). Formal assessment of sensation is difficult in children under the age of 3 years and in children with cognitive deficits. Goldner and Ferlic (1966) stated that the existing function and degree to which the impaired arm is used spontaneously will probably parallel the development of sensation. If the arm is ignored, then sensation is usually poor. Tizard, Pain, and Crothers (1954) concluded that sensory impairment is in some instances the main reason for disuse of the impaired arm. Sensory impairment may be the limiting factor for functional motor outcome expected from therapy, surgery, or casting. In the determination of sensory involvement, it is essential that the occupational therapist perform sensory testing, and a description by the parent of the child’s use of the impaired arm for activities of daily living is helpful.

**Age.** Candidates for surgery should be at least 5 years old. By that age, the central nervous system has matured and children are old enough to participate in their own rehabilitation (House et al., 1981; Keats, 1965; Samilson, 1966; Zancolli & Zancolli, 1981). Casting, however, may be successfully initiated as early as 15 months of age or when the child is beginning to creep or pull to a standing position. Early use of casting allows the child to spontaneously adapt to the casting process while the muscles, tendons, and joints are still pliable. Older children with cerebral palsy often have perceptually and psychologically disassociated themselves from their impaired limb and may not be receptive to learning how to use it. They may have developed compensatory patterns and may function independently in their daily living skills. This is not to imply that young children do not require time to adjust to therapy, but rather that they must be prepared to accept the feeling of sustained hypertonus. A positive rapport between the therapist and the child is important in preparation for and throughout the casting program. Generally, successful casting appears more likely for the younger than for the older participant.

**Case History**

I.K., whose condition was diagnosed as cerebral palsy with right spastic hemiplegia, was initially seen for occupational therapy at 15 months of age. She was very active. Her most reliable and frequent means of mobility was creeping, during which her right arm was positioned in internal rotation (see Figure 1). She also had begun to cruise around the furniture, holding...
her right foot in plantar flexion and her right arm and hand in flexion.

Active controlled movement of the right arm was limited because of increased tone. When she would attempt to reach overhead, the humerus was pulled into internal rotation, the elbow was flexed, and the forearm was pronated. I.K.'s active shoulder range while sitting was 0° to 100°. During upward reach, she compensated by elongating her trunk on the impaired side, elevating the right scapula, and flexing the right elbow. I.K. could isolate active flexion and extension of the right elbow. Grasp was uniformly associated with wrist extension, whereas release was accompanied by wrist flexion.

I.K. used a primitive gross grasp and release pattern with the thumb adducted. Associated reactions influenced the right arm, with strong flexion and pronation of the arm and hand. During play and stressful tasks, she showed associated reactions with increased spastic muscle tone in the affected side.

I.K. demonstrated a spontaneous protective response with the right arm, although most of these attempts were ineffective due to motor delay. Generally, I.K. used her sound hand for initiating reach and grasp and for manipulating objects and her impaired hand as a gross assist for holding objects (see Figure 2). She also used the impaired hand to assist in the transfer of objects during bilateral activities. During object manipulation, the shoulder girdle muscles were habitually adducted and the scapula was rotated downward. She was unable to volitionally move out of this posture.

An infant development specialist found I.K. to be functioning cognitively at her age level, although her vocabulary was somewhat limited. An only child, I.K. lives with her young, single mother, who is a high school graduate, and her maternal grandmother. I.K.'s mother's primary responsibility is taking care of I.K. She brings I.K. to weekly occupational therapy sessions.

Treatment

Phase 1

The aim of Phase 1 was to decrease abnormal tone, position the arm in alignment with the use of a long arm cast, and facilitate shoulder girdle movement.

The occupational therapy evaluation revealed increased spasticity of the right upper extremity, which prevented I.K. from reaching with forearm supination and elbow extension, and, above shoulder level, with external rotation of the humerus. I.K. had occupational therapy once a week for 1 month, during which time a neurodevelopmental treatment approach was used that focused on inhibition of abnormal patterns and facilitation of automatic patterns of movement to improve quality of arm placement and functional use of the right upper extremity. During therapy sessions, I.K. exhibited spontaneous use of the right upper extremity for bilateral tasks and used the hand as a gross assist to hold objects. While the right arm appeared relaxed during therapy, carryover outside of the session was minimal. Because of this, I.K. appeared to be a good candidate by which to determine the effects of casting on observable functional characteristics and arm-hand position during movement.

Once the physician's orders were written, a long arm cast was applied to I.K.'s right extremity, incorporating the elbow, wrist, and hand. This cast was selected because of its ability to control the degree of supination-pronation while positioning the elbow in extension and the wrist in neutral. The cast was applied with I.K.'s arm in the most comfortable position, which was the submaximal range. Submaximal positioning provided a mild stretch tolerable over a 1-week period, while preventing overstretching and trauma (microtear) of the soft tissue. The casting program lasted 4 weeks, with casts removed weekly and new ones applied to accommodate the increased range.

While wearing the cast, I.K. received outpatient occupational therapy for 2 hr once a week, which her mother preferred over a 1-hr session twice a week. Treatment was aimed at the development of shoulder girdle stability and control, strengthening of the trapezius and serratus anterior to facilitate upward rotation of the scapula, and improvement of humeral flexion and adduction and active overhead reach (see Figure 3).
Using a neurodevelopmental approach, I found that the cast served as an extra pair of hands during the handling session. I.K.'s mother was supportive of the casting process. She monitored the cast daily by checking the skin proximal and distal to the cast and encouraging I.K. to lift the casted arm when being assisted in dressing, when being carried, and during bilateral tasks. I.K. did not object to wearing the cast and adapted well to the weight. The cast did not appear to limit her ability to perform daily living skills (e.g., mobility, play, feeding).

**Phase 2**

The second phase of therapy was aimed at encouraging I.K. to use her hemiplegic arm frequently. A short arm cast was applied to the sound upper extremity, incorporating the wrist, hand, and thumb. This cast prevented I.K. from using her thumb and fingers for functional tasks. The cast was changed weekly for 4 successive weeks, thus permitting me to check for skin breakdown. During the casting process, I.K. continued to receive occupational therapy for 2 hr once a week.

Skin breakdown associated with pressure from the cast is a risk involved in casting. Casting of the sound hand may also greatly reduce the child's ability to function in his or her daily routine. Risk in this procedure may be minimized by close supervision and assessment of the casted arm during and after the casting program of Phase 1. The child that exhibits poor sensation and neglect may not be a candidate for this phase. In addition, if the child demonstrates poor arm placement for reach and grasp and release, then casting of the sound arm may only cause frustration. Factors that would indicate casting of the sound hand are (a) tolerance to Phase 1 of the casting program; (b) spontaneous use of the impaired arm during bilateral tasks; (c) ability to reach the impaired arm overhead and forward; (d) protective responses of the arm, although delayed; (e) gross grasp and release patterns; and (f) parental support.

Increased flexor spasticity in the muscles of the hemiplegic arm was produced by every activity of the sound hand, such as manipulation of toys, dressing, and other purposeful movement. Because I.K. was limited in the use of the casted sound hand for function during this phase, there was a significant decrease in associated reactions and an increase in spontaneous use of the hemiplegic arm noted during clinical treatment and reported by the mother. I.K. actively reached forward and grasped for blocks at tabletop level and reached for objects on the floor. I.K.'s mother was pleased with the child's ability to use the impaired arm. She reported that before the sound arm had been casted, I.K. had to be reminded to use it. The child adapted well to the cast and used the casted sound hand as an assist during play if focused on facilitating the placement of the hemiplegic arm by improving the strength and stability of the right upper extremity begun during Phase 1. The child assisted in her own treatment by using her impaired arm functionally and spontaneously during play and movement. Most impressive was I.K.'s spontaneous use of the impaired arm in transitional movements for all developmental postures (see Figure 4).

**Phase 3**

The aim of this follow-up phase of treatment was to maintain the gains achieved in Phases 1 and 2 and to maintain the length of elbow extension with forearm casted.
supination. The long arm cast used in Phase 1 on the right upper extremity was bivalved, and straps were applied. I.K. wore this bivalve splint every night and continued with her outpatient occupational therapy sessions, which had now been reduced to 1 hr per week.

The immediate result of the three-step casting procedure was overall improvement in I.K.'s strength and control of her hemiplegic arm. As measured at Week 4, I.K. used the increased strength of the scapula and rotator cuff muscles and resulting stability of the shoulder girdle to actively reach overhead with upward rotation of the scapula and humerus. The balance of tone in the proximal musculature and improved stability of the shoulder girdle allowed I.K. to place the impaired arm in a neutral position while creeping. By Week 8, I.K. spontaneously used the impaired arm in all planes of active reach during bilateral tasks.

I.K.'s sound left arm was always the preferred arm for functional tasks. The impaired right arm, however, was used more frequently as an assist. Associated reactions continued to occur during play with use of the sound arm during ambulatory or stressful tasks, but the retraction fixation pattern of the shoulder girdle was less severe than before casting.

After 1½ years of treatment, including continued use of the bivalve night splint, I.K. has maintained the gains noted at the beginning of Phase 3 and has continued to improve with weekly outpatient occupational therapy. Increases have occurred in (a) scapular stability and control during upward rotation, (b) use of humeral flexion and abduction, (c) use of the impaired arm when going from one position to another, and (d) spontaneous use of the impaired hand during bilateral manual activities (see Figures 5 and 6).

Discussion

Inhibitory casting of the upper extremity as an adjunct to conventional treatment is advantageous in several ways. First, it may improve joint stability, thus encouraging the child to use the arm during bimanual activities. Second, the cast anatomically aligns the position of the limb and thus may strengthen the opposing muscle group. Third, the additional proprioceptive input from the added weight and the static position held by the cast may assist improvement of the overall balance of the extensor and flexor muscles. Fourth, the impaired arm may be trained to work more efficiently.

Inhibitory casting is not a novel treatment approach; it is frequently used with contractures of the upper and lower extremity. The unusual experimental components of inhibitory casting in this case are in the use of established surgical criteria for the selection of an appropriate subject for casting; casting of the sound extremity to force the use of the affected limb; and prolonged use of a bivalve resting cast for nighttime use.

Figure 5. Transition from standing to sitting in a chair

Figure 6. I.K. reaching for an object with her hemiplegic arm.
According to Moore (1980), the concept of restoring may be used to optimize other senses or movement patterns of the nervous system. In the child with hemiplegia, a conscious effort to move the impaired limb results in increased muscle tone and abnormal movement pattern. As long as the sound arm is functional and efficient, the child will rarely rely on using the impaired arm. By casting the sound hand, the therapist is forcing the child to rely on alternative sensorimotor systems.

Phelps (1957) evaluated the long-term results of lower extremity surgical procedures used for cerebral palsy and ascribed the poor maintenance of gains to the lack of follow-up therapy. He stated that children who did well and maintained benefits of the surgical procedures to the lower extremities were those who wore a night brace throughout the period of growth. He reported no recurrence of contractures provided that the brace fit properly and was worn consistently. He hypothesized that the growth of the tendon may not be as rapid as that of the bones to which it is attached and that use of a night splint may maintain the length of a spastic tendon until the end of the growth period at age 16 to 17 years. Phelps attributed surgical failures primarily to inconsistent use of the night brace and a lack of sufficient motor power to maintain the correction. In keeping with Phelps’s recommendation, the continued use of a bivalve cast in the present study appears to have maintained the newly acquired muscle length, and continued outpatient occupational therapy has sufficiently assisted in the rebalance of motor power to permit the child to use the improved range gained by casting.

No specific criteria exist for the selection of the follow-up measure of the wearing of a bivalve cast after a casting program, because each child can respond differently to the casting program. The length of time that a child needs to remain in a bivalve cast or splint is difficult to estimate. A bivalve cast is used to maintain the length of the spastic muscle and range of motion. The therapist must continue to reassess the child, focusing on gradually diminishing the schedule of bivalve cast use as the child is able to maintain control when not wearing the bivalve cast. The bivalve cast may be needed later in the day, when fatigue seems to exacerbate the flexor pattern. Eventually, the cast may be worn only at night. Occupational therapists are continually testing new material and designs for use in follow-up care. A lightweight contoured orthotic material may be more comfortable to wear.

The criteria for the selection of children for upper extremity casting has been unclear and needs to be more fully defined. The present case report provides a basis for subsequent assessment of a casting approach. The child described in the present study fit the criteria for consideration of casting. She demonstrated activity of the opposing muscle groups, but her movement was limited by spasticity. Although sensory testing was not formally assessed, the child incorporated the affected arm during bilateral tasks and used the hand to assist with gross grasp and release of objects. When using the sound body side or forcefully grasping an object with the sound hand, the child showed an associated reaction, which produced increased spastic muscle tone of the impaired right arm. She also displayed a delayed protective response. She was a curious child and motivated to explore the environment. Most importantly, her mother was committed to the casting program and participated in the weekly therapy sessions.

Although the changes seen in I.K. were dramatic, a longitudinal study must acknowledge other factors influencing improvement. In this case, the primary factor is the effects of aging and of the neurodevelopmental treatment approach used during the weekly treatment sessions. Clinical experience, however, leads me to credit much of I.K.’s dramatic success and spontaneous use of her hemiplegic arm to the combined approach of casting, enforced use of the affected limb, and prolonged bivalve cast use at night. Formal research can examine which of these elements is key.

Summary

This case report presented a suggested protocol for the evaluation of potential casting candidates and illustrated the use of casting as an adjunct to therapy. The child’s and parent’s compliance is critical to the success of a casting approach. Although the child in the present study showed substantial improvement, the beneficial effect of upper extremity casting remains as initial clinical documentation, its application to a broad population is uncertain. In considering inhibitory casting for the child with hemiplegia and spastic cerebral palsy, we must recognize that other children may differ in characteristics that would affect the type and degree of response to casting. To achieve the desired results, the therapist must assess the child’s progress and modify the casting program in relation to that progress. As with any casting program, the therapist must observe proper casting procedures to prevent skin breakdown and must monitor the cast. If the patient and family members are not complying with the prescribed casting program, the therapist should initiate a more conservative treatment approach. Although no single case can determine whether a treatment procedure is effective or ineffective, this initial clinical documentation may serve to guide the development of inhibitory casting procedures for the treatment of persons with spastic cerebral palsy with hemiplegia. ▲
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References


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