CEREBRAL PALSY: Soft Tissue Surgical Management

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OVERVIEW

Dr. William Little originally described cerebral palsy (CP) in 1861, during a presentation to the Obstetric Society in London (1). It was known at this time eponymously as "Little's Disease." In 1889, Dr. William Osler coined the term cerebral palsy, and described the types of CP. CP is defined as a group of nonprogressive disorders involving development of posture and movement (2). Changes in motor function in CP occur in conjunction with alterations in sensation, cognition, communication, perception, behavior, or seizure disorder. Contractures develop secondary to spastic hypertonia or due to immobility. Studies show a prevalence of CP from 1.5 to over 4 of every 1,000 live births. Males are affected more than females. The exact pathophysiology of CP is not fully understood. Originally CP was attributed to traumatic birthing processes, however many other factors were found to more often cause CP including premature or postmature birth, maternal exposure, brain injury or abnormal development, cerebral leukomalacia, and cerebral infections or inflammation.

CLASSIFICATION AND GAIT PATTERNS

CP can be classified geographically or physiologically (3, 4). Geographically describes which extremities are affected as well as head and neck control. Physiological classification can be divided into spastic type, extrapyramidal types, and mixed type. Extra-pyramidal type includes athetoid, choreiform, ataxic, rigid, and hypotonic. Spastic CP is the most common type. It is a result of a reduction of inhibitory control in the central nervous system. A newer classification system, the gross motor function classification system (GMFCS), describes the level of activity of the patient. It is used for creating realistic goals with treatment for CP.

Gait changes are a result of spasticity and muscle contracture, most commonly in muscles crossing two joints (3). These include the psoas major, rectus femoris, hamstring, and gastrocnemius muscles. These muscles are the primary deforming forces in the sagittal plane. Toe walking is a common gait seen in younger patients (2). Intoeing is a common transverse plane deformity, usually the result of medial femoral torsion. Transverse and coronal plane deformities seen in the foot include equinovarus and equinovalgus. Equinovarus foot type is usually the result of a spastic or contracted posterior tibial or anterior tibial tendon. Equinovalgus results from equinus and stiff-knee gait, it is not due to a contracture of the peroneal muscles.

SURGICAL MANAGEMENT

Deformity in CP is commonly defined as a result of "muscle imbalance." However, studies have shown that while imbalance occurs, it is more important to correct all anatomic levels, the hip, knee, and ankle in conjunction with other specialists. It is vital to be aware of suprastructure deformity. In the past, Dr. Mercer Rang referred to surgery for CP as "birthday syndrome," as patients would undergo an operation every year of their life, spending the majority of their childhood in the hospital (5). Surgery, one anatomic level at a time can produce new deformities with each correction. It is now accepted that multiple-level surgery should be performed, also known as single-event multilevel surgery (SEMLS) (6). Norlin and Tkaczuk described this surgical approach in 1985 (7). SEMLS requires careful surgical planning, a team approach, and aggressive rehabilitation to be successful. A recent systematic review of SEMLS showed improvement in studies in regard to surgical technique and measurement of outcomes, with a need for more randomized-control trials. The review demonstrated overall SEMLS improves gait (8).

Equinus

Equinus is the most common deformity in CP. Patients with CP have longer Achilles tendons and shorter muscle bellies. The gastrocnemius is usually more contracted compared to the soleus, and gastrocenemius lengthening is the ideal procedure. Gastrocnemius recession is recommended in CP patients with spastic diplegia (9). A recent study showed correction of equinus in the long term for patients with mild to moderate equinus deformity undergoing SEMLS (10). Tendo-Achilles lengthening (TAL) is recommended in hemiplegia CP patients and in neglected equinus. TAL can result in calcaneal gait, creating worse deformity. Calcaneal gait is not always caused by surgical over-lengthening, but instead due to the changes in biomechanics and growth that cause the soleus tendon to over lengthen (2). It is also recommended that an open TAL be performed as opposed to percutaneously. Crouch gait is the most common complication of isolated TAL, therefore it is recommended that the procedure be performed in conjunction with other necessary procedures. One study found fewer complications when surgery was performed after a patient was 8-years-old (11).

Varus Deformity

Varus deformity can be secondary to spasticity of the posterior tibial or anterior tibial tendons, or due to femoral torsion. A spastic anterior tibial tendon causes a varus forefoot, as opposed to the posterior tibial tendon will cause a varus hindfoot deformity. Split-tendon transfers are successful at treating varus deformity (12-14).

The anterior tibial tendon typically is addressed in a split-transfer fashion (SPLATT), originally described by Kaufer in the 1970s (15). SPLATT as described by Hoffer (16) is performed with two incisions, the first located over the insertion of the tendon. The medial half of the tendon is left attached, while the lateral portion is transferred subcutaneously to the cuboid where a second incision is fashioned and the tendon is anchored.

The split posterior tibial tendon transfer (SPOTT), is used to address posterior tibial tendon (PTT) spasticity (14). The primary goal of this surgery is to eliminate varus positioning of the heel, while maintaining the PTT as a plantarflexor and to support the talonavicular joint. SPOTT as was originally described by Kaufer and since this time has been modified. The procedure begins with an incision at the navicular, where the tendon is split in half. The tendon can then be routed behind the lateral malleolus or transferred through the interosseous membrane. The tendon may then be attached to the peroneus brevis tendon proximally or distally, the lateral cuneiform, or the cuboid, as described in the literature. Originally, authors who advocated transfer through the interosseous membrane theorized it would correct the varus position as well as restore active dorsiflexion strength to improve equinus. One study compared these techniques, showing that regardless of technique similar outcomes were obtained (17).

Valgus Deformity

A valgus foot type is more common than varus (2, 3). Valgus foot type in CP can be unpredictable. Studies show that while a child may have a valgus foot type at a young age, they may eventually grow out of it, or result in a varus foot type. It is recommended that surgery not be performed before age 9-10 years. Primary treatment at a young age is orthotic therapy. Surgery is indicated if the patient has pain during gait, or if there is mechanical instability affecting gait. Many studies support lateral column lengthening with a posterior tibial tendon advancement if a prominent navicular is still present. Surgical intervention is based on age and level of deformity.

CASE STUDY

A 17-year-old female with spastic hemiplegia-variant cerebral palsy affecting her right lower extremity was seen for a chief symptom of tripping. She reported undergoing previous surgery at age 3, including right plantar fascia release and TAL due to severe toe walking. The patient did well with conservative measures until recently, with noted increase in pain, worsening deformity causing her heel to lift out of all shoes, and more frequent tripping. At the time of presentation, she was unable to perform most physical activity including sports and long walks over 15 minutes.

On physical examination, the patient had significant contracture along the right foot and ankle with anterior cavus deformity. Rigid hindfoot varus was noted on the right, with reducible forefoot valgus. Range of motion (ROM) at the ankle joint was limited in dorsiflexion to less than 5° due to soft tissue contracture. Manual muscle testing (MMT) demonstrated weakened peroneal and extensor tendons (MMT 4/5), as well as slightly weakened flexor tendons and posterior tibial tendon (MMT 4/5). A steppage gait with drop foot was noted during gait analysis. In stance, calf muscle atrophy was noted along the right leg.

Radiographic findings of the right foot and ankle demonstrated cavus changes with no arthritic change. Slight flattening of the talar dome was noted. Magnetic resonance imaging (MRI) was obtained to evaluate tendons for potential transfer surgery. It was determined that the posterior tibial tendon and flexor tendons were optimal donor tendons, based on MRI and clinical findings (Figures 1, 2).

Surgical correction was performed along the right foot and ankle including tendo-Achilles lengthening, plantar fascia release, posterior tibial tendon transfer (PTTT), and flexor digitorum longus tendon transfer (FDLTT). PTTT was performed in standard fashion with the FDLTT performed to stabilize the medial arch and limit abductory forces. Postoperative treatment consisted of non-weightbearing with cast immobilization for four weeks, followed by weightbearing transition in a walking boot over 3 weeks. Physical therapy was initiated immediately after cast removal. She is currently ambulating in shoes, with periodic bracing during physical activity. Her chief symptom of tripping has resolved, as has her pain along the right foot. At her two month follow-up, gait was pain-free without any tendency toward dropfoot; however, increased abduction was noted at this stage of the recovery (Figures 3, 4). She has continued physical therapy to strengthen to FDLTT site. If unsuccessful, joint arthrodesis or rearfoot osteotomy will be required.

Figure 1A. Preoperative image demonstrating cavus deformity with no arthritic change and tendon health.

Figure 1B. Preoperative image.

Figure 1C. Preoperative image.

Figure 2A. Anterior cavus foot position.

Figure 2B. Forefoot valgus position.

Figure 2C. Rearfoot varus with muscle atrophy.

Figure 3A. Postoperative radiograph demonstrating bone anchor position.

Figure 3B. Postoperative radiograph.

Figure 3C. Postoperative radiograph demonstrating bone anchor position.

Figure 4A. Postoperative reduction of anterior cavus.

Figure 4B. Maximal ankle dorsiflexion at 2 months post surgery.

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