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Surgical Treatment Guidelines for Digital Deformity Associated With Intrinsic Muscle Spasticity (Intrinsic Plus Foot) in Adults With Cerebral Palsy

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ABSTRACT

Intrinsic plus foot deformity has primarily been associated with cerebral palsy and involves spastic contracture of the intrinsic musculature with resultant toe deformities. Digital deformity is caused by a dynamic imbalance between the intrinsic muscles in the foot and extrinsic muscles in the lower leg. Spastic contracture of the toes frequently involves curling under of the lesser digits or contracture of the hallux into valgus or plantarflexion deformity. Patients often present with associated pressure ulcers, deformed toenails, shoe or brace fitting challenges, and pain with ambulation or transfers. Four different patterns of intrinsic plus foot deformity have been observed by the authors that likely relate to the different patterns of muscle involvement. Case examples are provided of the 4 patterns of intrinsic plus foot deformity observed, including global intrinsic plus lesser toe deformity, isolated intrinsic plus lesser toe deformity, intrinsic plus hallux valgus deformity, and intrinsic plus hallux flexus deformity. These case examples are presented to demonstrate each type of deformity and our approach for surgical management according to the contracture pattern. The surgical approach has typically involved tenotomy, capsulotomy, or isolated joint fusion. The main goals of surgical treatment are to relieve pain and reduce pressure points through digital realignment in an effort to decrease the risk of pressure sores and allow more effective bracing to ultimately improve the patient's mobility.

Cerebral palsy (CP) is a nonprogressive neurologic disorder that involves abnormal control of motor function (1–3). Deformities of the lower extremity in patients with CP are secondary to muscle imbalance (1,4). Adults with CP have often undergone operative and nonoperative treatment of hip, knee, and ankle contracture during childhood and adolescence in an effort to maintain ambulatory status. Toe contracture will typically become clinically relevant later in life when the deformity has become rigid or severe. In a case series of 200 children with CP, O'Connell (4) identified 93% with a dynamic or fixed deformity of the foot and ankle. The most frequent deformity was equinovalgus (4). As a child progresses through adolescence and into adulthood, the dynamic imbalance between the intrinsic and extrinsic muscles of the foot can progress to a rigid and fixed deformity of digits that were previously flexible (1,4,5). Adult patients with CP frequently present with severe and rigid contracture of the toes, similar to what Peimer (6) described in the fingers as intrinsic plus hand contracture, which involves metacarpal phalangeal joint flexion and proximal interphalangeal joint extension or hyperextension. Spastic contracture of the toes frequently involves curling under of the lesser digits or contracture of the hallux into a valgus or plantarflexion deformity. Patients will often present with associated pressure ulcers, deformed toenails, and shoe and/or brace fitting challenges and pain with ambulation or transfers. Intrinsic plus foot deformity can also be caused by other conditions associated with muscle imbalance, including spastic neurologic disorders, rheumatoid disease, trauma, and ischemia (6,7).

Adults with CP may not have access to the dedicated medical resources afforded to children with CP and therefore might seek treatment from general medical practitioners who may not fully appreciate the neuromuscular etiology of intrinsic plus foot deformity. It is important to differentiate digital deformity caused by spasticity from the more traditional forms of biomechanically induced hammertoes, hallux valgus, and hallux limitus because the effective treatment options, including surgery, differ according to the etiology of the deformity.

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The intrinsic muscles of the foot provide a stabilizing function through the metatarsophalangeal joints (MPJs) and interphalangeal joints (IPJs). A delicate balance exists between the intrinsic muscles of the foot and the extrinsic muscles of the leg. Muscle imbalance can result in biomechanically induced digital deformity and intrinsic plus foot deformity; however, the underlying mechanism of imbalance is quite different. Traditional hammertoe contracture is generally caused when the extrinsic muscles gains a mechanical advantage over the intrinsic muscles. This leads to extension at the MPJs and flexion at the IPJs (8). Traditional hallux valgus deformity involves lateral deviation of the great toe, which changes the pull of the adductor hallucis and flexor hallucis brevis (FHB) muscles into deforming forces (9). In contrast, the muscle imbalance in the intrinsic plus foot deformity is caused by spasticity and not biomechanical imbalance. The pattern of digital deformity is highly dependent on which intrinsic muscles have been affected by spasticity. For instance, spasticity of the lumbricales and interosseous muscles results in plantar contracture at the lesser MPJs and extension at the IPJs (Fig. 1). Spasticity of the adductor hallucis will result in hallux valgus, but spasticity of the FHB will result in hallux flexus through the first MPJ (Fig. 2). It is common that a patient with CP has combined spastic contracture of both the extrinsic and the intrinsic muscles, which can result in equinovarus contracture of the ankle and intrinsic plus deformity of the toes. This is more likely in patients who have not undergone posterior medial release of the ankle during childhood, have not responded to medical treatment of spasticity, or are minimally ambulatory owing to severe bilateral lower extremity contracture. The lack of regular weightbearing stretch allows progressive or recurrent contracture through the foot and ankle.

Patients with intrinsic plus foot deformity typically present with pain or sores associated with wearing braces or shoes. The clinical picture resembles that of a traditional hammertoe, bunion, or hallux limitus condition to the casual observer, with callused lesions, redness, bursitis, and ulcerations around the prominent joints or, perhaps, a dorsal bump, similar to that with hallux limitus. Recognizing the underlying neuromuscular involvement is essential to successful treatment. A gait examination and weightbearing radiographs will often be helpful to fully appreciate the spastic nature of the intrinsic plus deformity because standing will stimulate spasticity and provide a better view of the digital position when the patient is walking. Practitioners might be inclined to not perform the gait examination or weightbearing imaging studies for patients with CP who struggle with ambulation; however, these tests will be helpful in fully appreciating the extent of digital deformity in the spastic state.

Four patterns of intrinsic plus foot contracture have been observed by the authors, including global intrinsic plus lesser toe deformity, isolated intrinsic plus lesser toe deformity, intrinsic plus hallux valgus deformity, and intrinsic plus hallux flexus deformity. The isolated lesser toe deformity seems to primarily affect the second toe. It is common for a patient to have a combination of deformity patterns, especially intrinsic plus hallux valgus deformity plus an underlapping intrinsic plus second toe contracture.

The published studies of the hand have described various treatment options for intrinsic plus hand deformity, which have typically involved lengthening of the intrinsic muscle unit in the lesser fingers (7,10,11). The goal of surgical treatment of spasticity affecting the fingers is to restore finger function. The goal of surgical treatment of toe contracture is to straighten the toes to allow comfort with transfers, walking, and wearing braces and shoes. Surgical treatment of intrinsic plus foot contracture may, therefore, require a different approach than that used for hand surgery or traditional hammertoe and hallux valgus surgery. Focus has been lacking in published studies regarding surgical treatment of the various digital contractures associated with spasticity, leaving the surgeon without clear guidelines for treatment. The present case series provides clinical examples of 4 patients with intrinsic plus foot contracture, including the patient selection criteria for surgical management, procedure selection, surgical technique, and postoperative care protocols. Details regarding procedure selection according to the involved muscle contracture and goals for functional outcome in each type of intrinsic plus foot deformity are provided in the Table.

Fig. 1. Intrinsic plus foot deformity involving the lesser toes. Spasticity of the plantar intrinsic muscles of the lesser toes results in plantar contracture at the metatarsophalangeal joints and extension at the interphalangeal joints. This can affect 1 or more of the lesser toes and is distinctly different from the traditional hammertoe contracture caused by biomechanical imbalance in which the extrinsic musculature gains a mechanical advantage over the intrinsic musculature, leading to extension at the metatarsophalangeal joints and flexion at the interphalangeal joints. This photograph demonstrates intrinsic plus lesser toe contracture primarily affecting the second toe. Weightbearing stimulates spasticity, driving the tip of the affected toes into the ground and leading to pain at the tip of the toe, toenail problems, pressure sores, and difficulty with bracing and shoes.

Case Report

Patient 1

Patient 1 depicts a typical case of global intrinsic plus lesser toe deformity involving a 30-year-old male with CP. His main complaint