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Original Research

Treatment Strategies for Genu Recurvatum in Adult Patients With Hemiparesis: A Case Series

Malathy Appasamy, MD, Michelle E. De Witt, Nisha Patel, MD, Nancy Yeh, MD, Ona Bloom, PhD, Anthony Oreste, MD

Abstract

Objective: To report our clinical experience and propose a biomechanical factor—based treatment strategy for improvement of genu recurvatum (GR) to reduce the need for knee-ankle-foot orthosis (KAFO) or surgical treatment.
Design: Case series.
Setting: Outpatient clinic of a Department of Physical Medicine and Rehabilitation in an academic medical center.
Subjects and Interventions: Adult subjects (n = 22) with hemiparesis and GR who received botulinum injections alone or in combination with multiple types of orthotic interventions that included solid ankle-foot orthosis (AFO) ± heel lift, hinged AFO with an adjustable posterior stop ± heel lift, AFO with dual-channel ankle joint ± heel lift, or KAFO with offset knee joint. Biomechanical factors reviewed included muscle strength, modified Ashworth score for spasticity, presence of clonus, posterior capsule laxity, sensory deficits, and proprioception.
Outcome Measurements: Outcome factors were improvement or elimination of GR based on subjective assessment before and after the interventions by the same experienced clinician.
Results: More than one biomechanical factor contributed to GR in all patients. Botulinum toxin A injection was used in patients who had significant plantar flexor spasticity and/or clonus. Four types of orthotic interventions were used based on the biomechanical factor: solid AFO in patients with severe ankle dorsiflexion and plantar flexion weakness or clonus; hinged ankle joint with adjustable posterior stop in patients with less severe ankle dorsiflexion weakness in the absence of clonus; AFO with a dual-channel ankle joint for quadriceps weakness or severe proprioceptive deficits; and KAFO with offset knee joints in patients with Achilles tendon contracture or severe proprioceptive deficits. Adjunctive options included the addition of heel lifts and toeplate modifications. Combinatorial interventions of botulinum injection, modified AFOs, and heel lifts improved or eliminated GR and avoided the need for cumbersome orthotics or surgical interventions.
Conclusions: GR in hemiparesis is multifactorial and can be successfully controlled by using a conservative biomechanical factor—based approach and combined medical and orthotic interventions. An algorithmic approach and a prospective study design is proposed to determine a combination of effective interventions to correct GR.

Introduction

Genu recurvatum (GR) is an abnormal hyperextension of the knee, operationally defined as greater than 5° of hyperextension, characterized by the ground reactive force (GRF) line being anterior to the axis of the knee (Figure 1). Functionally, GR results in increased mechanical work of walking [1] and decreased gait velocity [2,3]. GR is a progressive, disabling, acquired deformity that occurs as a result of a wide variety of neuromuscular conditions, including upper motor neuron and lower motor neuron pathologies. Some examples of upper motor neuron pathologies that may cause GR include cerebral palsy [4,5], multiple sclerosis, and cerebrovascular accidents [4], where it has been reported to occur in 40%-68% of patients [6-8]. Several biomechanical factors have been enumerated as causative factors in this patient population [6]. In addition, GR may be caused by lower motor neuron conditions including poliomyelitis [9] and cauda equina syndrome [10].

Normally, full knee extension is accompanied by internal rotation of the femur on the tibial head. With GR, knee hyperextension does not trigger the femur to continue to roll anteriorly, and instead the femur tilts forward, creating anterior compression between the

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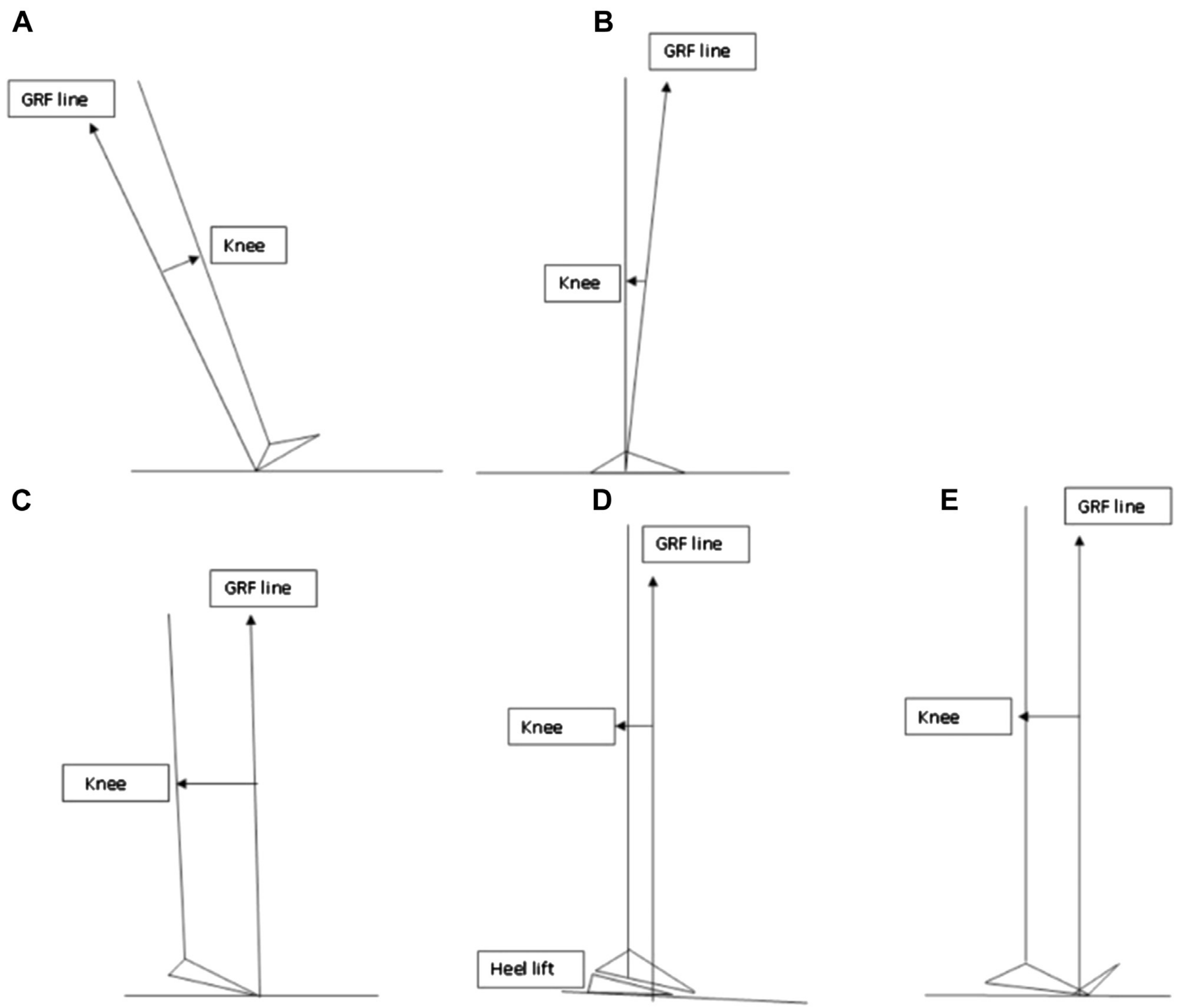

Figure 1. Line drawings of ground reactive forces (GRF).

femur and tibia. This hyperextended position, in conjunction with the normal femoral internal rotation, results in tension on the anterior cruciate ligament and posterior structures of the knee, ultimately leading to abnormal stretch of the posterior joint capsule and posterior ligaments of the knee [11]. With repetitive loading activities, especially activities of daily living such as walking, posterior joint laxity can develop from the tensile forces on the posterior capsule and structures, leading to knee joint instability [2,12].

Causes of GR are complex and multifactorial, and their relative contributions are debated [1,13-16]. In patients with hemiparesis, both proximal and distal biomechanical factors can occur individually or in combination [1]. Proximal factors that may drive muscle imbalance at the knee joint are quadriceps spasticity, which converts a normal eccentric quadriceps contraction to control knee flexion at heel strike to an abnormal hyperextension force [1], or weak hamstring muscles [13], which allow abnormal extension. Distal factors include equinovarus synergistic motor patterns, plantar flexor or posterior compartment spasticity [14,15], and restricted ankle dorsiflexion [17]. All of these biomechanical factors drive the GRF line anteriorly [7] (Figure 1C). The most commonly reported combination has been equinovarus synergistic motor patterns and quadriceps spasticity [15]. Loss of lower extremity proprioception, which can occur in stroke patients, is also associated with GR, because patients intentionally drive their knee into hyperextension either during late swing phase, to lock in extension, or by leaning their trunk forward at heel strike, to prevent the joint from collapsing [18]. This mechanism is similar to that of patients with lower motor neuron quadriceps weakness (ie, poliomyelitis and lumbar plexopathy).

Long-term consequences of GR stem from its propensity toward stretching the posterior capsule and ligaments of the knee, causing instability. GR also has