Walking Gait Before and After Chiropractic Care Following Fifth Metatarsal Fractures: A Single Case Kinetic and Kinematic Study

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ABSTRACT

Objectives: The purpose of this report is to describe the kinetic and kinematic analysis of walking gait following healed left proximal fifth metatarsal fractures.

Clinical Features: A 62-year-old female presented at a chiropractic clinic with concerns that recent metatarsal fractures had not fully resolved and reported abnormal gait due to pain and several weeks use of a "walking boot." The patient's walking gait was evaluated with a force-sensor treadmill and an inertial measurement unit motion capture system. Recordings were made before, at midpoint, and post-chiropractic care (11 visits total). Data were analyzed for spatio-temporal gait parameters, vertical ground reaction forces, and ranges of motion of the hip, knee, and ankle.

Intervention and Outcome: Pre-care, the patient's self-rated disability in walking was 50 out of 80 on a Lower Extremity Functional Scale, which improved to 80 out of 80, post-care. Her self-selected preferred walking speed increased, as did step length, cadence, and single support time. Increased symmetry was seen in timing of peak ground reaction forces, stance phase percentages of loading and pre-swing, and ranges of motion for hip and knee flexion and extension.

Conclusions: The patient recovered completely, and the post-injury kinematic and kinetic data allowed for quantification of gait patterns and changes in the clinical environment. (J Chiropr Med 2018;17:106-116)

Key Indexing Terms: *Chiropractic; Manipulation, Chiropractic; Gait; Walking Speed; Metatarsal Bones*

INTRODUCTION

Foot injuries and alterations in walking gait are some of the concerns brought to chiropractors. The fifth metatarsal is among the more commonly fractured bones of the foot, often either as avulsion or Jones fractures.[1-3] Jones fracture occurs at the metaphyseal–diaphyseal junction of the fifth metatarsal, an area with a low blood supply that is prone to prolonged healing or nonunion. Other types can occur in the head, neck, and mid-shaft.[1-5] Younger patients with metatarsal fractures are more often male, but older patients are more often female.[6]

Associated signs and symptoms include pain, swelling, tenderness, difficulty walking, and bruising. There is considerable variation in management, especially if a Jones fracture is suspected.[1,3,4,7-12] Since 1984, Torg et al's[13] recommendation of conservative treatment for Jones fractures, with a non-weight bearing cast for a period of 3 to 12 weeks, has been frequently followed.[5,10,12] In 2017, Brogan et al[14] concluded that all fifth metatarsal fractures can be safely managed with immediate full weight-bearing in an orthotic boot without adverse effects and that often no long-term review is needed. Most experts agree, however, that if the injury involves a displaced bone, multiple breaks, or fails to adequately heal, then surgery may be needed.[1-3,5,12,15]

Metatarsal fractures might result in alterations of walking. Bauer et al[16] reported gait asymmetry in 11 out of 20 patients with fifth metatarsal fractures, most with no visible gait disorder. Kösters et al[17] reported slower walking associated with multiple metatarsal shaft fractures. Queen et al[18] found that women with a history of metatarsal stress fractures exhibit decreased forefoot forces.

Chiropractic literature describes management of foot and ankle conditions.[19-25] However, only 1 chiropractic publication concerns fifth metatarsal fracture, which is only in terms of diagnostic imaging, not condition management.[26] The purpose of this report is to describe the kinetic and kinematic investigation of post-injury walking gait of a patient, before and after receiving chiropractic care.

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Case Study

Patient Characteristics

A 62-year-old female presented to the research center with concerns that recent injuries of her left foot had not fully resolved and reported abnormal gait, due to pain and several weeks use of a "walking boot." Acute inversion injury and Jones fractures of the proximal fifth metatarsal had occurred twice within 6 months. For both fractures, she received conservative treatment with non-weight-bearing casts for periods of several weeks. At 10 weeks from the onset of the second injury, she was released from care. But, despite residual pain and swelling and the occurrence of the second fracture at the same location as the first, no physical therapy was recommended by the orthopedist.

The patient previously had a hairline fracture of the same fifth metatarsal 40 years earlier and a fracture of the fifth proximal phalanx 5 years earlier. Other medical history included Hashimoto's Thyroiditis, menopause, psoriasis, and vitamin D insufficiency. Prescription medications included levothyroxine, ergocalciferol, and topical cortisone.

The investigation of the participant's post-injury kinetic and kinematic data was prospectively planned by the researchers and then approved by the Life University Institutional Review Board. At the patient's presentation to the research center, the investigators explained the protocols, had the patient sign an informed consent, and asked the patient to complete a Lower Extremity Functional Scale (LEFS) questionnaire.[27] According to the LEFS, she scored a 50 out of a possible 80.

Overview of the Human Gait Cycle

"Kinetic" refers to the forces involved in the actions and motions to be discussed; "kinematic" refers to descriptions of the motions themselves.[28-30] To discuss gait, we start with the right hip flexing forward and the event of the right foot contacting the walking surface (or ground), most commonly seen as a heel strike, which marks initial contact and the beginning of stance phase (Figs 1A and 2A). As the body moves forward, its center of mass drops slightly, and rapid loading of weight onto the right limb generates a vertical ground reaction force (VGRF) at the point of contact with the ground. Most people will show a sharp increase of force at heel strike (a heel strike transient, Fig 2A).[31] The moment at which the magnitude of the VGRF reaches its maximum level is noted as the event of peak force 1 (Fig 2B), which can be about 120% of body weight.[30] During this loading phase, both feet are in contact with the ground (double limb support or double support). Weight gradually transfers to the advancing right limb until the trailing left foot lifts and enters swing phase, beginning a period of single limb support for the right side (Fig 1B, C, and D). As the left limb swings forward, the body's center of mass rises slightly, such that VGRFs decrease slightly in mid-stance (Fig 2C), often to approximately 80% of body weight.[30] During this time, left knee flexion allows the left foot to clear the floor (Fig 1B and C), and the right ankle moves into dorsiflexion (Fig 1C). As the weight of the body moves over and past the foot below it, the right limb moves to "push-off," with the ankle actively moving into plantarflexion. This period is marked by a second increase in VGRF, up to the event peak force 2 (Fig 2D). As the left foot ends its swing and contacts the ground again, there is a second period of double support. The left foot begins to receive a transfer of weight (Fig 1E), and the right foot undergoes a gradual "unloading" of force until the event of toe-off. The events are repeated for the left side until the right foot touches again, completing 1 stride.[28-30]

Evaluation

The participant was asked to walk on a treadmill with force sensors under the treadmill belt (zebris Medical GmbH, Isny im Allgäu, Germany; Noraxon USA, Scottsdale, Arizona); available data included VGRF and a number of spatial and temporal gait parameters. The treadmill was started, and she was guided to find her preferred walking

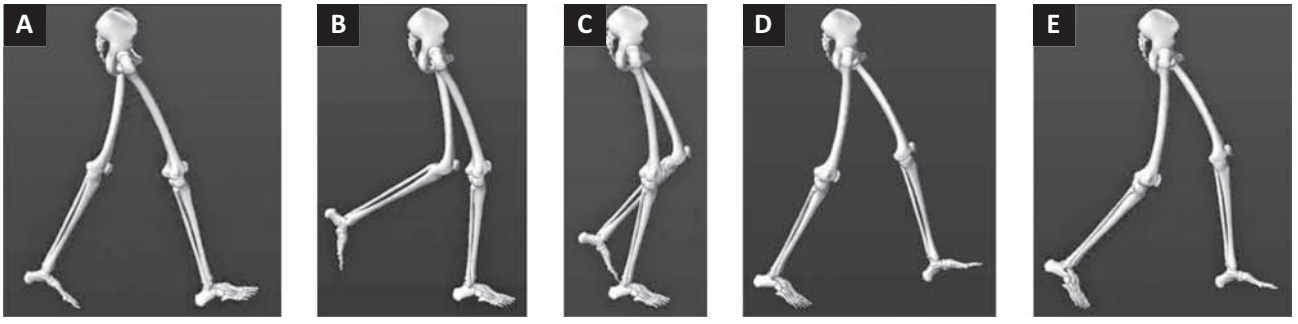

Fig 1. *Excerpts from video generated by the myoMOTION software capturing its "skeletal avatar" in various positions withn a gait cycle. These are from this case participant's second post-care assessment. A, Initial contact (heel strike) of the right foot; B, early in mid-stance of the right foot, demonstrating maximum left knee flexion; C, The "legs adjacent" position of mid-stance; D, During "push-off" of the right foot, just before initial contact of the left foot; E, Pre-swing for the right foot, just before toe-off, in the loading phase for the left foot.*