Multisegmental Foot and Ankle Kinematics in Hallux Valgus Before and After Surgery

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ABSTRACT INTRODUCTION:

Hallux valgus (HV) is a common first metatarsophalangeal (MTP1) joint deformity characterized by lateral deviation of the large toe, medial deviation of the first metatarsal, and hallux pronation [1,2]. Progressive subluxation of the MTP1 joint is common and results in attenuation of the medial soft tissues and contracture of the lateral soft tissues. The flexors and sesamoid complex of the great toe are laterally displaced, and this displacement further increases the valgus moment at the MTP1 joint. This worsens the deformity resulting in subluxation, articular incongruity, and arthritis. The consequent pathologic anatomy leads to biomechanical dysfunction and impairment [3]. The common etiology is constricting footwear but some authors suggest intrinsic factors for HV. Pathologies located more proximally such as hypermobility of the first metatarsocuneiform joint, pes planus, hindfoot pronation, and Achilles tendon contracture have been postulated to play a role in the development of HV [1]. Given the numerous potential pathological elements in HV, authors have described a vast number of operative procedures to address the deformities. Surgical correction of HV most commonly involves structures such as the distal metatarsal, the proximal phalanx, and soft tissues around the MTP1 joint; and frequently consists of a combination of operative procedures. Alterations in plantar loading and gait kinematics in HV have been studied in the past [4-7] but literature on quantitative characterization of segmental foot motion is limited. Given its vital role in normal gait, it is important to understand how hallux function is impaired and how the rest of the foot and ankle is affected in patients with this disabling condition. Equally important is how surgical treatment affects these segments. This study aims to describe segmental forces and kinematics pre and after surgery in a population of patients with HV. The results may help clarify the kinematic segmental interaction of this condition.

METHODS:

This prospective study involving 10 feet in 9 subjects with HV (“HV” group) was approved by the Institutional Review Board of the Medical College of Wisconsin. To determine kinetics and temporal-spatial parameters, pre- and post-operative foot and ankle motion analysis was conducted using the Milwaukee Foot Model (MFM). The MFM enables 3D evaluation of motion of four segments of the foot and ankle (tibia, hindfoot, forefoot, and hallux). Position and range of motion (ROM) values during the seven phases of gait as described by Perry [8] were compared between the pre- and post-op populations using paired nonparametric methods. Pre- and post-op measures were also compared to a population of healthy ambulators (“Normal” group) using unpaired nonparametric methods.

RESULTS SECTION:

In the HV group, the hallux demonstrated a valgus position throughout gait (Fig. 1). A significant decrease in transverse plane ROM was seen from initial swing through midstance. Limited sagittal and coronal ROM was also noted in stance and swing. The forefoot demonstrated a less plantarflexed position with significant decrease in sagittal ROM from pressing through midstance. Diminished forefoot varus was noted at initial swing. Hindfoot ROM in the transverse and coronal planes was diminished from midswing through preswing. Hindfoot position was not significantly different from healthy ambulators. Persistent tibial internal rotation was observed, reaching significant levels at terminal swing. Tibial transverse ROM was decreased from midswing through midstance. Post-op hallux position showed significant correction towards that of healthy ambulators. Other segment positions and ROMs were not significantly affected from pre-op to post-op. Pre-op temporal-spatial parameters showed significant decreases in walking speed and stride length which did not change post-operatively.

DISCUSSION:

A valgus position of the hallux was maintained throughout gait. With this may be expected toe off through swing in the Normal population, the normal varus motion occurring from swing to midstance was lost as the medially located abductor hallucis tendon displaced plantarward in HV leaving the capsule as the only medial restraint [1]. Hallux ROM limitation may be due to soft tissue and articular pathologies [3,9] although the limited ROM across all segments may be the result of decreased walking velocity in the presence of a diseased MTP1 joint. Post-operative kinematics showed hallux position was restored to normal after surgical correction of the HV. This finding was confirmed by significantly improved post-operative radiographic measurements. Hallux pronation is a typical clinical finding that was also observed in the kinematics; while its positional abnormality did not reach statistical significance, it is noteworthy that the position shifted towards normal after surgery. Sagittal plane abnormalities in position and ROM of the forefoot suggest flattening of the longitudinal arch. This supports the association of HV with pes planus and tibialis posterior tendon abnormalities [1,3,10]. The forefoot valgus shift on plantar loading is consistent with the sagittal deformity. The decreased tibial internal rotation supports observations of plantar load shifting laterally from the first metatarsal to the lesser toes frequently resulting in metatarsalgia [4-7]. This is mainly due to displaced toe flexors and reduced great toe flexor function at toe off; it may also account for the reduced velocity and stride length in patients with HV as described previously [3,4,9,11]. Post-operatively, however, proximal segment kinematics remained unchanged. The persistence of dynamic abnormalities in the proximal segments following surgery suggests that pathologies seen more proximally may indeed play a role in HV. This further emphasizes the complex nature of operative treatment.

REFERENCES:


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