THE EFFECTS OF ADULT ACQUIRED FLATFOOT DEFORMITY ON TIBIOTALAR JOINT CONTACT CHARACTERISTICS

Mark A. Friedman, Louis F. Draganich, Brian Toolan, and Michael E. Brage

Section of Orthopaedics and Rehabilitation Medicine, Department of Surgery
The University of Chicago, Chicago, Illinois 60637
Email: ldragani@surgery.bsd.uchicago.edu

INTRODUCTION

The acquired flatfoot deformity is a condition whose principle etiologies can be traumatic, spontaneous, degenerative or neuropathic (Henceroth & Deyerle, 1982) and can severely limit a person’s ability to stand or walk comfortably (Mann & Thompson, 1985). The condition arises as an insidious collapse of the longitudinal arch as a result of a progressive valgus deformity of the calcaneous, plantar flexion of the talus, and abduction of the forefoot (Mann & Thompson, 1985). One of the most commonly recognized causative factors is deficiency of the tibialis posterior or rupture of the tendon (Deland et al., 1992, Henceroth & Deyerle, 1982, Mann & Thompson, 1985) which acts as a principle inverter and adductor of the foot. This leads to increased loads in the local soft tissues which may stretch or tear and the described deformity may develop (Mann & Thompson, 1985).

Osteoarthritic changes in the ankle have been observed in patients with long term deformity (Jahss, 1991), yet little is known of the mechanical effect of acquired flatfoot deformity on the ankle joint. The objective of this study was to characterize the changes in contact pattern and load distribution of the tibiotalar joint with an acquired flat foot deformity.

The changes in the tibiotalar contact characteristics were investigated using fresh frozen cadaver ankle specimens to model the acquired flatfoot deformity. The deformity was simulated by sectioning the tendons and ligaments of the ankle and foot that normally support the longitudinal arch. The cadaver model simulates physiologic conditions by loading the ankle axially in a neutral position to two times the body weight of an average man. This load reproduces the actual forces experienced by the articular surfaces during normal gait generated by both ground reaction forces and muscle contractions (Stauffer et al., 1977). Measurements of the tibiotalar joint contact characteristics were made using pressure sensitive film.

We hypothesized that the acquired flatfoot deformity would result in significant alterations in the tibiotalar contact characteristics. Specifically, a lateral shift and reduction in area of the contact distribution was expected as a result of the everted position of the calcaneus and consequent malalignment of the joint surfaces.

PROCEDURES

Eight fresh frozen cadaver ankle specimens were obtained for testing. Each ankle had been radiologically screened and manually examined to exclude previous fractures, osteoarthritis, or other signs of defects. Threaded rods were cemented into the tibial and fibular canals with epoxy.

Hermetically sealed film packets were constructed of low pressure, Pressensor film (Inteque Resources Corp., Fort Lee, NJ, USA). The film packets were placed into the tibiotalar joint anteriorly through an
arthrotomy incision. Pins were used to place reference marks and to locate the film packet within the joint in a reproducible manner.

Loading of the specimen was performed on a materials testing device (Instron model 8500 plus, Instron Corp., Canton, MA). The tibial rod was mounted vertically in the machine and the foot rested in zero degrees of flexion on a steel plate supported by ball bearings assuring that a purely axial load was applied to the specimen. An aluminum plate was rigidly fixed to the tibial rod and was secured to the fibular rod with an adjustable nut. Bending of the plate could be adjusted to transfer 10% of the total load to the fibula during testing.

The testing procedure involved pre-loading the ankle to 50 N. Then, a 0.5 second ramp load was applied to a peak load of 1,350 N. This maximum load was held for 0.5 second, and then returned to 50 N in 0.5 second. This loading sequence was applied three times to obtain three sets of film prints for each intact specimen. An established ligamental release procedure was then employed to create a severe flatfoot deformity (Deland et al., 1992). The loading sequence was again applied three times to obtain three sets of film prints for the flatfoot specimen.

The pressure imprints were scanned forming a 600 dpi 256 gray scale image (0=black, 255=white). The images were analyzed using Global Lab Image version 2.20 (Data Translation Inc., Marlboro, MA, USA) software. Area, mean pressure, and center of contact area measurements were then made. A high pressure region was defined as the 90th percentile of darkest pixels and was used to determine the peak pressure and location of peak pressure.

These measurements were averaged for the three film prints for each condition, intact and flatfoot. Average values of change in the measured variables were tabulated. Each specimen served as its own control and paired t-tests were performed. Differences were considered to be statistically significant at the \( \alpha=0.01 \) level of significance.

RESULTS AND DISCUSSION

The flatfoot condition resulted in significant lateral shifts of 5.28 mm (\( p=0.0002 \)) in global contact area and 11.26 mm (\( p=10^{-6} \)) in the location of peak pressure. The flatfoot condition also resulted in a significant, 35% (\( p=0.005 \)), reduction in contact area.

These findings support our hypothesis and provide insight into the probable mechanism of injury to the articular cartilage in long term flatfoot deformities. This model will further provide a tool for the evaluation of various corrective measures, including reconstructive techniques.

REFERENCES