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Coronal plane ankle alignment, gait, and end-stage ankle osteoarthritis

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SUMMARY

Objective: Unilateral ankle osteoarthritis (OA) is a debilitating condition which may lead to limb deformity, severe pain, and functional disability due to tibiotalar malalignment and gait dysfunction. The purpose of this study was to determine if coronal plane alignment (varus, valgus, or neutral) of the ankle resulted in different spatial-temporal gait mechanics, clinically-assessed function, and self-reported function in patients with end-stage ankle OA.

Methods: Following informed consent, 96 patients with end-stage unilateral ankle OA were radiographically categorized as having varus, valgus, or neutral tibiotalar alignment. Each subject completed the foot and ankle disability index (FADI) questionnaire to assess self-reported function. The spatial-temporal parameters of interest (stance time, step length, stride length, stride width, single-support time, double support time, and walking speed) were assessed while the subject walked at a self-selected speed.

Results: The varus group performed the timed up and go test significantly faster than the other groups ($P = 0.05$). All other variables were similar between the three alignment groups.

Conclusion: There was little difference in gait mechanics and function between patients with end-stage OA based on coronal plane ankle alignment suggesting that factors other than coronal plane alignment contribute to diminished function.

Introduction

Unilateral ankle osteoarthritis (OA) is a debilitating condition which may lead to deformity, severe pain, and functional disability[1]. Unlike other major joint arthroses, ankle OA tends to be post-traumatic, which often affects younger populations with longer projected lifespans[2]. Important secondary causes of ankle arthritis include traumatic injury, sepsis, rheumatoid arthritis, osteonecrosis, neuropathic arthritis and gout[3]. Each of these conditions can cause or exacerbate underlying tibiotalar malalignment in this population. While ankle OA is less prevalent than knee or hip OA, the degree of physical impairment associated with ankle OA is similar to that reported in patients with end-stage kidney disease[4], congestive heart failure[4], and end-stage hip arthritis[5].

The principal goals of any ankle reconstruction surgery will be to recreate (1) a quasi-anatomical reconstruction of the natural geometry, (2) a stable and plantigrade foot position to restore acceptable gait function, and (3) the return of more normal soft tissue function around the ankle[6]. The two options for surgical treatment of end-stage ankle OA are either total ankle arthroplasty or ankle arthrodesis. Currently, the choice between these two surgical options is controversial, particularly as it pertains to addressing the aforementioned surgical goals. Based on the currently available literature, total ankle replacement continues to be performed less frequently than ankle arthrodesis because studies that examine gait and self-reported function following total ankle replacement are limited and longevity of the prosthesis has been short[7–9]. For these reasons, further data are needed on the clinical, functional, and gait mechanics outcomes of total ankle replacement as an effective treatment for ankle OA. In order to demonstrate the effectiveness of a surgical procedure at restoring gait and function, pre-operative gait and functional data is helpful for both group and longitudinal comparisons.

Previous studies on coronal plane ankle alignment and OA highlight a clear association between the two. Valderrbano *et al.*[10] discussed the etiologies of ankle OA and found no difference in hindfoot malalignment distribution among etiologic groups, but did find that the average tibiotalar alignment was varus in their patient population. Interestingly, Harrington[11] reported that

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chronic ligamentous instability, which can lead to degenerative ankle arthritis, was more likely to be associated with a varus deformity. Horisberger *et al.*[12] tied hindfoot malalignment in arthritic ankles to alterations in plantar pressure distribution with the varus alignment being the most prevalent in their patient population. Still, valgus deformities do occur in patients with ankle OA. Pagenstert *et al.*[13] hypothesized that valgus deformities were better compensated by the subtalar joint during end-stage OA because the natural range of ankle eversion motion exceeds the range on inversion motion. Ultimately, changes in ankle alignment in the sagittal plane, as shown by Kura *et al.*[14], alter the contact frequency within the ankle joint, either lateralizing contact with eversion or medializing contact with inversion.

The goal of this study was to determine if coronal plane alignment of the tibiotalar joint (varus, valgus, or neutral) resulted in significantly different spatial-temporal gait variables, clinically-assessed function, and self-reported function in patients with end-stage ankle OA. The current study is an important preliminary step in addressing whether coronal plane alignment influences spatial-temporal variables during walking. Should alignment affect gait, the data may help to identify prospectively which patients will respond more favorably to total ankle arthroplasty.

Methods

Patient recruitment

For this prospective, non-randomized study, 100 consecutive patients from a larger clinical series of patients with end-stage ankle OA, who were scheduled for total ankle arthroplasty between 2007 and 2009, were recruited. Prior to data collection, all study participants signed an informed consent that had been approved by the medical center institutional review board. Patients were excluded from this study if they were unable to walk without the use of an assistive device, if they had bilateral ankle OA and/or a history of previous ankle arthrodesis. Out of the original 100 patients who were consented to participate in the study, 96 were included in the final analysis as four failed to meet the inclusion/exclusion criteria for the study. Out of the 96 patients tested 13 had a prior total knee arthroplasty (TKA) and 12 had a prior total hip arthroplasty (THA).

Clinical and radiographic assessment

Using standard weight bearing radiographs each patient was categorized as having varus, valgus or neutral tibiotalar alignment according to the method of Kim *et al.*[15] Patients were divided into groups based on their tibiotalar alignment as follows: (1) Valgus: greater than 5° of valgus, (2) Neutral: between 4° of varus – 4° of valgus, (3) Varus: greater than 5° of varus. The anteroposterior tibiotalar angle was defined as the angle between the long axis of the tibia and a line perpendicular to the articular surface of the dome of the talus on the weight bearing anteroposterior radiographic view (Fig. 1)[15]. The categorization process of the 96 subjects in the study resulted in 27 valgus, 34 neutral, and 35 varus patients. Following informed consent, each subject completed the foot and ankle disability index (FADI) questionnaire to assess self-reported function. The FADI (recently revised and now called the Foot and Ankle Ability Measure) consists of 26 questions about activities of daily living and has been previously reported in an ankle arthritis population[16].

In addition, each subject completed a series of clinically relevant functional tasks. The patients completed a timed up and go test (TUG) that consisted of rising from a standard arm chair, walking 3 m and then returning to the standard arm chair as quickly as possible. The TUG has high reliability and correlates well with other standard functional measures such as gait speed, self-report, and clinical report indices of function and is predictive of who can safely ambulate[17]. In addition, the TUG has been previously reported to be one of four factors that is important to assess in patients with end-stage ankle OA[18].

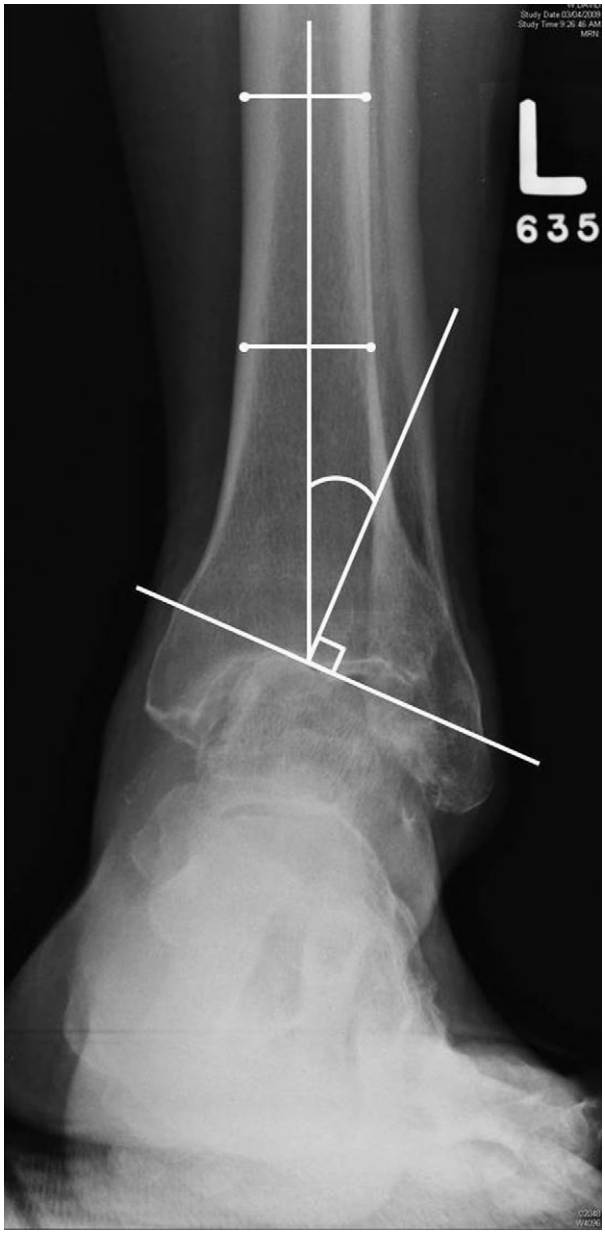

Fig. 1. Example of the radiographic assessment to determine the coronal plane alignment.

Walking assessment

Each patient was asked to complete a walking assessment during his or her visit. Spatial-temporal gait data were assessed using an eight-camera three-dimensional videographic motion analysis system sampling at 120 Hz (Motion Analysis Corporation; Santa Rosa, California) and four force plates (AMTI, Watertown, Massachusetts). Each subject completed seven barefoot walking trials at a self-selected walking speed along a 30-m walkway. Data were collected bilaterally, however, only the limb with end-stage OA was