HYPOTHETICAL DESIGN FOR ANKLE-SUBTALAR JOINT PROSTHESIS

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INTRODUCTION

The ankle and subtalar joints together form the most distal principal joint complex of the lower limb. Proper function of these joints is essential for normal gait. Disease or injuries of these joints leads to pain, stiffness or abnormal motion (degenerative arthritis). Thus far, there are two common surgical approaches to the treatment of degenerative arthritis in the foot and ankle. The joint can be either be fused, or it can be replaced by an artificial prosthesis of some sort. In recent years, success has been achieved in developing various ankle prostheses for the treatment of ankle arthritis. Fairly normal function can be now been achieved for patients with isolated ankle arthritis by using these prostheses.

However, there has been as yet been very little work done on the subtalar joint due to its complex joint surfaces and limited understanding of the kinematics. The objective of this study is to design a prosthesis that has similar design consideration and dimensions as the present successful generation of ankle prostheses, but that also allow some degree of motion along the axis approximating that of the subtalar joint. The approach has several potential advantages owing to that prosthesis design and implantation technique is similar to presently available implants, which should translate into less difficulty in learning the technique (for the surgeon), less complication and a lower rate of morbidity.

METHODS

As part of the process of designing the prosthesis, a cadaveric analysis of ankle-subtalar kinematic was performed. The aim of the experiments was to a) validate previous description of hindfoot kinematics; b) determine various parameters which would help us to design the prosthesis; c) provide a benchmark for comparison after design and implementation of a prospective implant.

The ‘Flock of Bird’ (FOB) electromagnetic measuring system (Ascension Technology Corporation, Burlington, VT, USA) was used to measure and track the kinematic data. In order to passively generate plantarflexion-dorsiflexion and eversion-inversion movement in the ankle-subtalar joint complex, a custom designed rig was built. (Fig. 1). Because the measurement system would be affected by distortion to an electromagnetic field, all components of the rig were built of non-metallic materials.

Total ten trans-knee amputation cadaver specimen was tested. Each specimen was thawed for 24 hours prior to the experiment. Each specimen was then prepared. A 9mm drill was used to create a pilot hole in the articular surface of the tibial plateau and the shank rod threaded in. The three receiver fixtures were then inserted into the tibia, talus and calcaneus. In the neutral position, each of the four landmarks was then
digitized five times using the pen device attached to the last FOB receiver. At the same time, data from the other three receivers was simultaneously collected. This procedure allowed us to create a reference for the three receivers with respect to the anatomical coordinate system.

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**Fig. 1:** Experimental Rig for vitro experiment on foot/shank specimen

**RESULTS AND DISCUSSION**

The results indicate that during the dorsiflexion-plantarflexion, at maximum plantarflexion of the foot, 29.2° of plantarflexion of the calcaneus with respect to the tibia is associated with 27° of plantarflexion at the ankle joint and with 2.1° of plantarflexion at the subtalar joint. At maximum of dorsiflexion of the foot, 18.6° of dorsiflexion of the calcaneus relative to the tibia is associated with 19.1° of dorsiflexion at the ankle joint and with 0.6° plantarflexion at the subtalar joint. The data correlates well with previously published kinematic description of the ankle subtalar joint complex. Both the ankle and subtalar joint show 6 degree of freedom motion an multiaxial characteristics.

**SUMMARY**

The end results of this study are the fabrication of two prostheses milled out of aluminum. The final products could be used as real implants, and have not been validated even for kinematics in cadaveric experiments. However, this study does review pertinent literature and knowledge, which leave open the possibility that a novel solution may be available for the treatment of plantar arthritis. Factors that predict for success in prosthesis design in the ankle include minimal bone cuts, semi-constrained articulation, non-cemented bone interface, and preservation of the malleoli and collateral ligaments. In addition, it is unlikely that a successful anatomical prosthesis will ever be found for treatment of subtalar arthritis. Because of the close proximity of the ankle and subtalar joints, a single prosthesis that can support rotations along the both axes may not be achievable.

**REFERENCES**