Biomechanical Comparison of Three Methods of Anterior Tibialis Tendon Transfer for Club Foot Correction

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Disclosures:

Introduction: Anterior tibialis tendon transfer is a common procedure used to treat a relapsed clubfoot deformity. Several transfer techniques have been described; however, there is currently no general agreement as to the best method to achieve balance of the foot using this transfer.

Garceau [1] initially described a method of transfer in which the anterior tibialis tendon is redirected laterally above the extensor retinaculum level and attached to the base of the fifth metatarsal. Later Garceau and Palmer described anchoring the transferred tendon into the cuboid (Garceau transfer).[2] In this procedure, three incisions were used; one over the anterior tibialis tendon, a second over the anterior aspect of the lower leg, and a third over the lateral aspect of the foot. The tendon was detached from its insertion, delivered into the proximal incision, and then passed beneath the ankle retinaculum to the lateral incision where it was anchored into the foot.

Ponseti and Smoley [3] later modified this technique by instead attaching the tendon to the third cuneiform (Ponseti transfer). This operation was done using two dorsal incisions; one over the anterior tibialis tendon and the other over the third cuneiform. The tendon was passed subcutaneously and secured through a drill hole in the cuneiform.

Another method that is commonly used is a split anterior tibialis tendon transfer, in which only half of the tendon is rerouted and attached to the cuboid (split transfer). This procedure was originally described for the treatment of a spastic equinovarus foot in children who have cerebral palsy [4], but has subsequently been described to treat residual dynamic forefoot supination following clubfoot treatment.[5] This procedure uses three incisions, similar to those described for the Garceau procedure. In this study, we compared the influence that each of these three techniques (Garceau, Ponseti and split) had on the subtalar motion and forefoot position using a cadaveric model. Our hypothesis was that the three techniques would have comparable influence on subtalar and forefoot motion.

Methods: Ten fresh-frozen cadaveric lower legs, disarticulated at the knee, were used. An aluminum ring with pointed screws was used to secure the proximal tibia to the load actuator of a biaxial MTS 858 biaxial servohydraulic load frame (MTS, Minneapolis, MN). The anterior tibialis tendon was sutured to a rope at the level where the tendon transfers into the muscle. This rope went through a pulley system and was attached rigidly to a load cell connected to the load frame of the MTS. By raising the actuator of the MTS, the tension in the tendon via the load cell caused the foot to flex.

Motion of the foot was measured using an Optotrak 3020 Motion Capture System (Northern Digital Inc, Waterloo, Ontario, Canada). Motion tracker flags were rigidly attached to the medial tibia, the distal head of the first metatarsal, the lateral calcaneous, and the medial talus by cortical screws. Ankle joint motion (plantar/dorsal flexion) was measured using the flags in the tibia and talus, subtalar joint motion (valgus/varus) was measured using flags in the talus and calcaneous, and forefoot motion (pronation/supination) was measured using flags in the tibia and first metatarsal. Motion was measured continuously throughout testing.

Each foot was loaded at a rate of 0.005 Hz until it reached a maximum of 150 N of tension or 15 degrees of dorsiflexion. After the initial “Intact” loading, the anterior tibialis tendon was removed from the bone, shifted subcutaneously, and attached to the third cuneiform (Ponseti transfer). The tendon was attached to the bone by adding a suture to the tendon, wrapping it around a screw in the cuneiform, and tightening the screw. The foot was again loaded to a maximum of 150 N or 15 degrees dorsiflexion. The tendon was then removed from the cuneiform and rerouted back to its initial position. It was then rerouted proximally by pulling it out of the proximal incision and fed back under the extensor retinaculum in more lateral position to be attached to the third cuneiform again (Garceau transfer). After loading the foot, the tendon was again removed from the cuneiform and placed back in its initial position. The tendon was then split and a suture was attached to each half. One half was then proximally rerouted to the cuboid and the other left in the initial position where it was attached originally (split transfer). The sutures were attached to the bones again by wrapping the suture around screws and tightening them. The split tendons length was adjusted to approximately equalize their tension similarly as it is done during actual surgery. The foot was then loaded a final time. The position of the joints with the ankle in a neutral (0 degrees flexion) position was used to normalize the motion data. This position was determined using horizontal and vertical laser levels aligned with the axes of the foot and tibia. Positive or negative values in the initial hanging position (0 N) or in the maximum dorsiflexion position (150 N or 15 degrees dorsiflexion) corresponded to the direction of motion (Figures 1 and 2). No neutral position for subtalar joint or forefoot motion was measured, rather relative valgus/varus and pronation/supination movements were recorded from the ankle neutral flexion position. A paired t-test was used to compare motion values between each surgery at the maximum flexion position.

Results: All of the specimens tested dorsiflexed above the neutral position. Two of the ten specimens reached 15 degrees of
dorsiflexion, while the remaining reached an average of 9 degrees of dorsiflexion (range: 1 to 14 degrees). Overall, in the maximum dorsiflexed position, we found that all three procedures resulted in a similar amount of valgus of the subtalar joint (Figure 1). Although, while there was less than 2 degrees of difference between them, we found that the Ponseti and split transfers had a significantly greater amount of valgus motion than the Garceau transfer. Compared to the intact tendon, all three procedures resulted in pronation of the forefoot, with as much as a 10 degree difference (Figure 2). Furthermore, the Ponseti and Garceau transfers resulted in a greater amount of pronation of the forefoot than the split transfer, with a 5 degree difference between them (Figure 2). In fact, compared to the neutral position, the split transfer did not provide any pronation beyond neutral.

**Discussion:** The Ponseti method is now the standard treatment for idiopathic clubfoot. Relapsed deformity with residual dynamic forefoot supination has been reported in up to 54% of patients initially treated using the Ponseti method.[6] Accordingly, anterior tibial tendon transfer is more commonly performed. In maximum ankle dorsiflexion, all procedures provided valgus directed motion of the subtalar joint. Forefoot pronation was greater with the Garceau and Ponseti procedures, compared to the split transfer. In addition, there is some suggestion that little, if any, pronation provided by the split procedure.

**Significance:** From neutral to maximum ankle dorsiflexion, the Ponseti transfer provided better subtalar valgus motion and forefoot supination than the other transfers. Since our data suggests that transfer of the entire tendon provides better correction than the more technically demanding split transfer, the more simple procedure is preferable in the management of a relapsed clubfoot deformity.

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**References:**
Figure 2. Forefoot Motion

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