What Is The Optimal Penetration Depth For "All-Inside" Meniscal Repairs?

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Introduction: All-inside meniscal repairs have been developed to address concerns associated with the traditional “inside-out” technique. The devices used to execute all-inside repair consists of a piercing needle loaded with suture and anchors, an anchor deployment ram, and a penetrating depth restriction sleeve. Before piercing the meniscus and deploying the suture anchor at the joint capsule periphery, the operating surgeon must first set the correct depth of anchor deployment using the penetration restriction sleeve. Even though the distance between the injury site and menisco-capsular junction is arthroscopically visible, the distance from the inner junction to the outer capsule wall is unknown leaving the surgeon to use the maximum setting and rely on tactile feedback. Due to this relatively blind deployment of the anchor, there is significant risk of harm to adjacent structures secondary to under or over-penetration of the posterior wall. This study was undertaken to define the optimal depth setting of meniscal repair devices under fully saline-inflated conditions for both medial and lateral meniscal repairs.

Methods: 16 fresh cadaveric knee specimens were obtained from 15 male donors (avg 49.6yrs range 20-64yrs) and prepped for simulated surgery using typical arthroscopic techniques. After inflating the joint with saline, the 3D surfaces of the menisco-capsular junction and the posterior capsule were digitized with a navigated stylus and a 12-camera infrared motion analysis system to determine the capsular wall thickness in the direction of normal arthroscopic approach. This was accomplished by using the scope camera to advance the stylus through each anterior portal until the tip was visibly in contact with the menisco-capsular junction. The 3D position and direction of the stylus tip and shaft were then recorded with the infrared system. For both the medial and lateral menisci, 3 equidistant points were digitized along the posterior horn, posterior mid body, and collateral regions. A typical inside-out posterior incision was then made to allow access and digitizing of the capsular wall. The resulting point clouds and vector directions were then imported into modeling software (RapidForm) that allowed the construction of a 3D model within which precise digital measurements could be made. (Fig1). As a means of validation, “all inside” meniscal repairs were performed on 7 knees using a FasT-fix device (Smith & Nephew). The device was set on the maximum setting and the needle tip of the device was placed at the red/white meniscal junction and advanced until the tip was seen to protrude through the capsular wall. Physical measurements of needle protrusion though the capsular wall and needle insertion distance from the menisco-capsular junction were taken and then subtracted from the device setting for comparison to the digitized results.

Results: The distance from the capsular junction to the peripheral capsular wall was averaged for the posterior horn, mid, and co-lateral ligament regions for both approaches separately. Similar capsular wall thickness averages were seen for each approach with the exception of the collateral region (Charts 1 & 2). In the 7 repaired knees, the same differences were observed between anatomic locations and vector direction; however, the actual depth of penetration of the needle exceeded the predicted distances by an average of 1.9mm in the medial meniscus, and 2.3mm in the lateral meniscus.

Discussion: Our method allowed for precise oblique measurement of the posterior capsular in the direction of surgical approach while fully inflated in an operative position. When applying our results to practice, consistent bulging of the soft tissue was seen to occur prior to piercing of the needle. Therefore, when performing an all-inside repair of the medial or lateral meniscus, these results can be used to calculate the depth setting for safe optimal placement of the suture anchors. Capsular thickness during arthroscopic repair measures approximately 6-8mm with 2-3mm additional depth needed to ensure complete penetration of the capsule. Surgeons can simply add the desired distance away from the menisco-capsular junction where the device will be inserted to find the optimal setting for anchor deployment. Assuming that the device is used for historically repairable tears (red-red or red-white), depth setting greater than 16mm should not be necessary.

Significance: This study provides the operating surgeon with a recommended depth setting to lessen the risk injury by over/under penetration.

Acknowledgments:

References: Figure 1. 3D computer model of menisci, peripheral posterial walls,and vector measurement.
Chart 1. Medial capsule wall thickness when approached from each portal
Chart 2. Medial capsule wall thickness when approached from each portal.