Meniscal Allograft Size Can Be Predicted by Height, Weight, and Gender

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Purpose: Our purpose was to determine if height, weight, and gender can be used to accurately predict proper meniscal allograft dimensions. **Methods:** Data were obtained from the Joint Restoration Foundation (AlloSource, Centennial, CO) regarding meniscal size and patient characteristics from meniscal donors. Donor height, weight, sex, age, and anatomic meniscal dimensions were recorded for 930 donor menisci in 664 patients. Multivariate regressions were completed using gender, height, and weight as independent variables and lateral meniscus length, lateral meniscus width, medial meniscus length, and medial meniscus width as dependent variables. The regression formulas were then reapplied to the data in order to produce estimated meniscus dimensions based on donor height, weight, and gender. A 90:10 split of the data was used to validate the regression models. Predicted meniscal size was then compared to actual meniscal size and the results compared to current measurement techniques. **Results:** Regression formulas showed the ability to predict meniscal size based on gender, height, and weight with standard deviations (SDs) equal to or less than current radiographic techniques (SD, 6.4% to 8.2%). Average differences between predicted size and actual size ranged from 5.2% to 6.5% for length and 5.2% to 6.0% for width. Patient height was found to be a much more powerful predictor of meniscal size than patient weight. Data from the 90:10 split of data validated the model on an independent sample. These validated outputs were then compared to contemporary techniques and found to have lower SDs and average error rates in the majority of cases. **Conclusions:** We have proposed a validated regression model that uses height, weight, and gender variables to accurately predict required allograft meniscal size. We compared it against previously published data for radiographic and magnetic resonance imaging sizing techniques and found it to produce results that were, overall, slightly more accurate. **Clinical Relevance:** This model provides a novel method for sizing meniscal allografts. **Key Words:** Allograft—Meniscus—Size—Transplant.

Meniscectomy has the potential to have devastating long-term consequences in young patients. Many procedures have been developed to address the changes caused by a meniscectomy, including tendon autograft meniscal replacement, meniscal engineering, and meniscal transplantation.[1,2] Of these, meniscal transplantation has received the most attention and clinical applicability in recent years. It is an evolving technology that has shown clinical and physiologic efficacy in various studies.[3-8] There have also been numerous techniques and modifications proposed for the transplantation procedure.[9] This continuous refinement has been fueled by ongoing research and the contributions of expert opinion.

Preoperative sizing of the allograft is one aspect of meniscal transplantation that is continually debated.[10,11] The importance of correct sizing has been considered by many authors and highlighted in recent biomechanical studies completed by Dienst et al.[12] and Al-

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halki et al.[13] Currently, there are two predominant methods for sizing the allograft: radiographic analysis, as proposed by Pollard et al.,[15] and magnetic resonance imaging interpretation as proposed by Haut et al.[16] In Pollard et al.'s method,[15] there is a correction made for magnification, and the width is then calculated on the anteroposterior radiograph of the knee by measuring from the tibial metaphyseal margin to the peak of the tibial eminence. The length is measured on the lateral radiograph and a 70% adjustment is made for the lateral meniscus and an 80% adjustment is made for the medial meniscus. Haut et al.[16] used MRI parameters of the meniscus in order to predict the required allograft size, and most recently Prodromos et al.[17] confirmed the accuracy of MRI in this application. However, the majority of contemporary studies have used radiographic measurements for sizing. Both methods have shown utility; however, they also have substantial standard deviations (SDs) of measurement and relatively large average error rates.

The need for accurate meniscal allograft size estimation and the purported error associated with contemporary sizing methods led us to investigate other feasible techniques for accurately determining the size of the required meniscal allograft. Furthermore, it has recently been suggested that patient height and weight may provide data that can be used to calculate accurate size estimates of meniscal allografts.[18] In the current study, 930 menisci have been analyzed in the context of the donor's height, weight, and gender. It is our hypothesis that this demographic data can be used to develop a reproducible formula that can be applied to future meniscal allograft sizing.

METHODS

Donor height, weight, sex, age, and gross anatomic meniscal dimensions were obtained from the Joint Restoration Foundation (AlloSource, Centennial, CO) for 930 menisci in 664 patients. The menisci were collected and processed using the following protocol: basic dissection of knee en bloc tissue was used to open the capsule; the menisci were evaluated for tears, hard spots, and weak insertion points; measurements of the length and width of each meniscus were taken before the menisci were released from the surrounding tissue of the proximal tibia; and the menisci were released from the tibia.

The grafts were cleansed and rinsed before being sent though a purge/soak process to facilitate the removal of blood and lipids form the bone block and cleaning of the tissue. The grafts were cultured and the dimensions were measured with calipers before being placed into the final packaging. According to American Association of Tissue Bank standards, the grafts were stored at or below −40°C until implantation.

The donors for the menisci had died of various conditions and circumstances that were not made known to us. Once their menisci were harvested, patient demographic information was obtained. Heights, weights, and gender were recorded from the medical record or, if the medical record did not contain this information, from the patient's drivers license.

The information for 930 menisci was entered into an Excel database (Microsoft, Redmond, WA), including meniscal length (anteroposterior), meniscal width (mediolateral), meniscal side, meniscal compartment, donor height, donor weight, donor age, and donor gender. These data were analyzed with Excel to calculate significance values ($P < .05$) and perform multivariate regression analysis for the different sets of data.

Statistical Analysis

Multivariate regression analyses were used to examine the association between the individual outcomes, which included lateral meniscus length, lateral meniscus width, medial meniscus length, and medial meniscus width and the predictors (height and weight). These associations are examined separately in male and female subgroups.

The data were randomly split into a sample set and a validation set in a 90:10 ratio. The multivariate regression models were fit on the sample set and the fitted models were then used to predict the outcome variables (lateral meniscus length, lateral meniscus width, medial meniscus length, and medial meniscus width) on the validation set. The residuals—that is, the difference between actual and predicted values—were then computed only on the validation set. The mean absolute differences and SDs were then calculated on these validation residuals. The process of randomly splitting the data in a 90:10 sample and validation sets was then repeated 50 times, and the average mean absolute differences and SDs of the ratios over these repetitions were obtained.

The results of these analyses based on height and weight were then compared with the published results from Pollard et al.[15] and Shaffer et al.[19] using the criteria established in those articles. Therefore, SD percentages were calculated and compared to Pollard et al.'s results.