

Analysis of the Cross-Sectional Area of the Adductor Longus Tendon

A Descriptive Anatomic Study

Eric J. Strauss, MD, Kirk Campbell, Joseph A. Bosco,* MD
From the Department of Orthopaedic Surgery, NYU-Hospital For Joint Diseases, New York, New York

Background: Strain injury to the adductor longus muscle is a common cause of groin pain in athletes and generally occurs in the proximal portion of the muscle, near its origin from the anterior aspect of the pubis. The composition and cross-sectional anatomy of this muscle's origin has not been previously described.

Hypothesis: We hypothesize that the adductor longus muscle origin is composed mainly of muscle fibers and that the tendon composes only a small part of the cross section at the origin of the muscle.

Study Design: Descriptive laboratory study.

Methods: We harvested 42 adductor longus muscles from 28 cadavers and measured the cross-sectional dimensions of the tendon with microcalipers. Next, we determined the relative contributions of the tendon and muscle fibers to the cross-sectional anatomy of the muscle using optical scanning. These 2 sets of measurements were obtained at 3 locations: at the muscle origin and 1.0 and 2.0 cm distal to the origin.

Results: The average length and width of the tendon was 11.6 and 3.7 mm, respectively, at the origin. The average cross-sectional areas of the tendon were 49.3, 27.9, and 25.7 mm² at points 0.0, 1.0, and 2.0 cm from its origin, respectively. The origin of the adductor longus muscle was composed of 37.9% tendon and 62.1% muscle tissue. At 1.0 cm from the origin, the percentage of tendon decreased to 34%. At 2.0 cm from the origin, the tendon composed 26.7% of the cross section.

Conclusion: The cross-sectional area of the tendon of the adductor longus muscle is relatively small. The muscle origin is composed predominantly of direct attachment of muscle fibers.

Clinical Relevance: Knowledge of the cross-sectional anatomy of the adductor longus muscle at its origin may help clinicians better understand the complex nature of injuries in this area.

Keywords: adductor longus strain; groin injuries; anatomy

Groin pain in athletes is a common problem with varying and complex origins, running the gamut from posterior inguinal wall injury to conditions involving the symphysis pubis.^{1,6,8} Strain injuries of the adductor longus muscle also play a key role in the origin of athletic groin pain.

Groin injuries are relatively common among athletes, often leading to significant amounts of missed playing time and a prolonged period of rehabilitation.^{1,6,8} Epidemiologic studies have demonstrated that 2% to 5% of all athletic injuries occur in the groin area, most frequently during participation in sporting activities that require rapid change of direction such as ice hockey, rugby, and football and in kicking sports such as soccer and swimming.^{8,12,15} The complex anatomy of the hip and groin region coupled with the overlapping symptoms and examination findings seen in athletes with groin pain often make an accurate diagnosis and appropriate management difficult for the treating sports medicine clinician.

*Address correspondence to Joseph Bosco, MD, 301 East 17th Street, New York, NY 10003 (e-mail: boscoj01@med.nyu.edu).

No potential conflicts of interest declared.

Adductor longus strain is the most common cause of chronic groin pain in athletes, accounting for up to 62% of cases in a study by Renstrom et al.^{8,12} Typically, patients with adductor strain injury complain of aching groin or medial thigh pain, accentuated during adduction of the lower extremity against resistance.^{1,8} Tenderness to palpation and focal swelling along the course of the muscle may be seen on physical examination in addition to objective decreases in adduction strength.¹ Injuries to the adductor longus muscle generally occur in the proximal portion of the muscle, near its origin from the anterior aspect of the body of the pubis.^{13,18} Although several factors, including the superficial location of the muscle, its relatively small origin, and poor proximal vascular supply, have been suggested to contribute to the frequent involvement of the adductor longus in groin injuries, the exact cause of adductor strain has yet to be determined.^{6,18}

The previous report of the anatomy of the proximal adductor longus muscle measured the length and width of the tendon only in 2 dimensions.¹⁸ No attempts to characterize the 3-dimensional anatomy of the tendon have been reported. We believe that the relative contribution of the myofibers and tendon to the cross-sectional anatomy of the adductor longus is important. The cross-sectional contribution of the tendon has implications in the ability of surgeons to affect a repair and reattachment of the muscle in cases where it avulses from its insertion site.¹⁴ The purpose of the current anatomic study is to characterize the cross-sectional anatomy of the muscle at its insertion site.

MATERIALS AND METHODS

We harvested the proximal 10 cm of 42 adductor longus muscles from 28 cadavers. There were 17 males and 11 females with an average age of 71 years. Each muscle was orientated and cut into 3 samples. The cross-sectional samples were obtained at 3 points: 1) The origin of the muscle, 2) 1.0 cm distal to the origin, and 3) 2.0 cm distal to the origin. The samples were then placed in a solution containing 5% isopropyl alcohol, 5% glycerol, and 0.1% benzakonium chloride. They were stored at room temperature. The samples were then sectioned with a microtome in preparation for microscopic analysis. Gross measurements of the tendon length and width for each specimen at each harvest location were recorded by a single observer using a digital caliper with a resolution of 0.1 mm and an accuracy of 0.05 mm (Avenger 6" Digital Caliper, Boulder City, Nev). Three measurements were made for each specimen at each location, with the mean length and width recorded. The specimens were then prepared for histologic evaluation using both hematoxylin and eosin and picosirus red staining. The picosirus stain, which stains collagen, enables the best differentiation between the muscle and tendinous portions of each specimen (Figure 1).

Slides were digitized and then analyzed using SigmaScan Pro Image Analysis software (SyStat Software Inc, Point Richmond, Calif). Analysis included determination of the cross-sectional area of the adductor longus

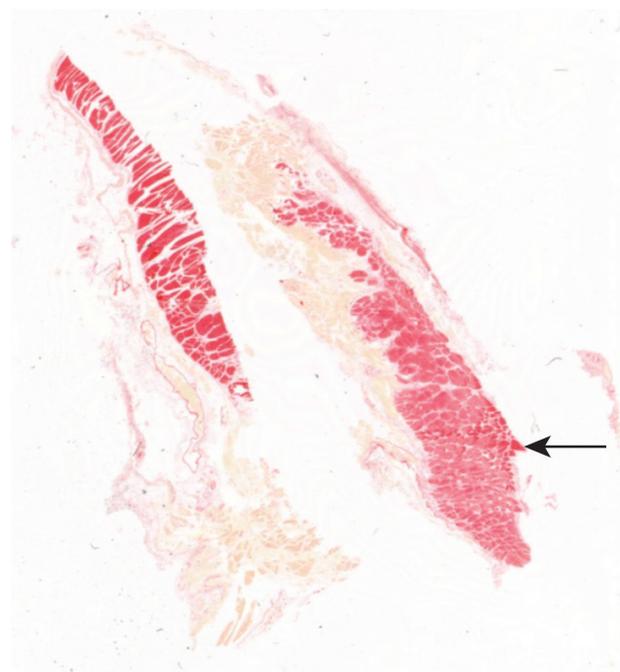


Figure 1. Picosirus red staining of an adductor longus specimen harvested 1 cm from the origin. The dark red stained area (indicated by black arrow) represents the tendinous component of the specimen, whereas the lighter red stained tissue is the muscular component. This sample specimen had a cross-sectional area of 32 mm² of which 24.1% was tendinous and 75.9% was muscle tissue.

tendon for each specimen. To ensure consistency in the cross-sectional area measurement, the analysis program was calibrated to recognize the color threshold for the tendinous portion of the specimen, which was a brighter red than the muscular portion.

RESULTS

Microcaliper measurements of the stained adductor longus tendon showed that the absolute tendinous cross-sectional area decreased with increasing distance from origin. The average dimensions of the tendon measured 11.6 mm (± 5.1) in the medial-lateral dimension (width) and 3.7 mm (± 1.1) in the anterior-posterior dimension (depth) at the origin. The width decreased to 2.4 mm (± 0.8) at 1.0 cm and 2.2 mm (± 0.4) at 2.0 cm from the origin, respectively. The average cross-sectional dimensions of the tendon were 49.3, 27.9, and 25.7 mm² at points 0.0, 1.0, and 2.0 cm from its origin (Table 1, Figure 2).

Image analysis demonstrated that the origin of the adductor longus muscle was composed of 37.9% tendon and 62.1% muscle tissue (standard deviation, $\pm 13.0\%$). At 1.0 cm from the origin the percent tendon decreased to 34% (standard deviation, $\pm 15.6\%$). At 2.0 cm from the origin,

TABLE 1
Gross Measurements of the Proximal Adductor Longus Tendon

Sample	Tendon Length (mm)	Tendon Width (mm)	Area (mm ²)	Standard Deviation (length/width)
0 cm (origin)	11.6	3.7	49.3	± 5.1/1.1
1 cm from the origin	11.6	2.4	27.9	± 9.9/0.8
2 cm from the origin	11.6	2.2	25.7	± 3.6/0.4

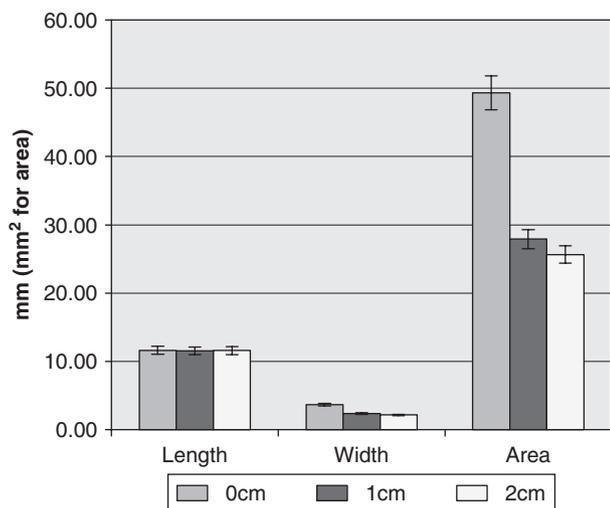


Figure 2. Comparison of length, width, and cross-sectional area of the proximal adductor longus tendon. The cross-sectional area and width decreased with increasing distance from the pubic origin. (Error bars represent standard deviation, which was determined to be 4.6, 4.5, and 3.9 for the length; 1.1, 2.2, and 0.9 for the width, and 5.1, 9.9, and 3.6 for the area, respectively).

the tendon composed 26.7% of the cross section (standard deviation, ± 13.8%) (Table 2; Figure 3).

The tendon was located superficially, on the anterior portion of the musculotendinous unit when viewed in cross section. As is reflected by its dimensions, the tendon appeared flat. The average ratio of the mediolateral dimension (width) to the anterior-posterior dimension (depth) of the tendons was 3:1.

DISCUSSION

Our understanding of the complex nature of groin pain in athletes is evolving. From “sports hernias” to muscle strains, the varying causes of groin pain are being investigated. We are just beginning to decipher the complex

TABLE 2
Mean Cross-Sectional Area of the Proximal Adductor Longus Tendon Specimens as Determined by Digital Image Analysis

Sample	Tendon Area (% of sample)	Standard Deviation
0 cm	37.9%	± 13.0
1 cm	33.9%	± 15.6
2 cm	26.7%	± 13.8

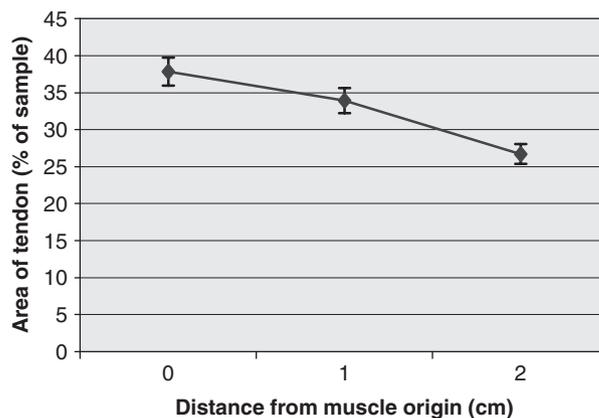


Figure 3. Decreasing cross-sectional area of the tendon with increasing distance from the muscle origin.

interaction between the many anatomic structures that contribute to this clinical entity. This paper focuses on the cross-sectional anatomy of the adductor longus to help guide the treatment of injuries to this muscle.

The adductor muscle group in the medial compartment of the thigh, composed of the adductor longus, adductor brevis, and adductor magnus, together with the lower abdominal muscles, acts to stabilize the pelvis during activity. The adductors function to adduct the femur and counteract the rotation of the pelvis, especially during the double support phase of gait, when the anterior lower extremity is flexed and the posterior lower extremity is extended at the hip.¹⁸ Innervated by the obturator nerve, the adductor longus is a large, fan-shaped muscle that arises from the anterior aspect of the body of the pubis just inferior to the pubic tubercle and expands distally to attach to the linea aspera of the femur. The firing of the adductor longus in kicking sports and athletic activities that require quick starts and rapid change of direction with pivoting probably contributes to its frequent injury, predominantly in the form of muscle strain.^{8,9,15,18}

Muscle strains typically occur at the myotendinous junction, usually during eccentric contraction.^{1,3} An incomplete soft tissue disruption, which corresponds to a first or second degree strain, often leads to fluid collection at the site of the tear acutely, which can extend along the epimysium and subcutis resulting in inflammation and edema.^{2,10,17,18}

Diagnosis is made based on patient history, clinical symptoms, and localized tenderness on physical examination. Ultrasonography and magnetic resonance imaging may be used to confirm clinical suspicion and may also provide prognostic information.^{11,16}

Adductor longus strain is a common cause of groin pain in the athlete, leading to significant amounts of missed playing time. The strain injury most often occurs in the proximal portion of the muscle-tendon unit, close to the insertion site at the pubis.^{1,6,8,18} The musculotendinous junction of the adductor longus is a site subjected to considerable mechanical stress during the transmission of the force of muscular contraction to the tendon.¹⁸ The tendinous origin of the adductor longus has been described as being small, flat, and narrow, ranging from 2 to 4 cm in length.⁵ Tuite et al¹⁸ performed an anatomical evaluation of the proximal musculotendinous junction of the adductor longus in 37 cadavers and found that a variety of anatomical variants and anomalies, ranging from uneven junctions to tendinous defects, were present, potentially contributing to the variable location of strain injuries.

In our descriptive anatomical evaluation of the proximal adductor longus tendon, we found that the cross-sectional area of the proximal tendon was small to begin with and decreased with increasing distance from the origin. At 2 cm from the origin at the pubis, the cross-sectional area of the tendon decreased by 30%. This small cross-sectional area in close proximity to the musculotendinous junction may limit the ability of the surgeon to achieve secure operative fixation of the muscle to its origin.

The initial management of muscle strains includes rest, ice, and compression in an effort to limit the hemorrhage and edema associated with strain injury. After the resolution of pain, patients may be advanced to gentle range of motion exercises. The use of nonsteroidal anti-inflammatory medications for muscle strains has been questioned in the orthopaedic literature. Mishra et al⁷ evaluated the impact of nonsteroidal anti-inflammatory drugs on healing after muscle injury in a rabbit model. The authors found that although short-term recovery after muscle injury was seen with treatment, the longer-term muscle function was adversely affected compared with untreated controls. Once range of motion has been fully regained, rehabilitation focuses on muscle strengthening to help prevent injury recurrence. Return to activity should be allowed once the athlete is completely pain free and has regained full strength and range of motion, which may take up to 8 weeks for acute strains and up to 6 months for chronic strains.^{1,8} In a randomized clinical trial evaluating the effectiveness of active physical training in the management of chronic adductor-related groin pain, Holmich et al⁴ found that active strengthening of the adductor complex allowed 79%

of athletes to return to athletic activity without residual groin pain at a mean of 18.5 weeks.

Based on our findings, we believe that the decrease in cross-sectional area of the proximal adductor longus tendon seen between the pubic origin and the musculotendinous junction is small. This small cross-sectional area may contribute to the difficulty seen with attempted repair of this muscle and its generally favorable response to nonoperative treatment. Accurate diagnosis and an appropriate management protocol may help speed functional recovery and prevent recurrence.

REFERENCES

- Anderson K, Strickland SM, Warren R. Hip and groin injuries in athletes. *Am J Sports Med.* 2001;29:521-533.
- Boutin RD, Newman JS. MR imaging of sports-related hip disorders. *Magn Reson Imaging Clin N Am.* 2003;11:255-281.
- Garrett WE Jr. Muscle strain injuries. *Am J Sports Med.* 1996;24(Suppl):S2-8.
- Holmich P, Uhrskou P, Ulnits L, et al. Effectiveness of active physical training as treatment for long-standing adductor-related groin pain in athletes: randomised trial. *Lancet.* 1999;353(9151):439-443.
- Kalebo P, Karlsson J, Sward L, Peterson L. Ultrasonography of chronic tendon injuries in the groin. *Am J Sports Med.* 1992;20:634-639.
- Lynch SA, Renstrom PA. Groin injuries in sport: treatment strategies. *Sports Med.* 1999;28:137-144.
- Mishra DK, Friden J, Schmitz MC, Lieber RL. Anti-inflammatory medication after muscle injury. A treatment resulting in short-term improvement but subsequent loss of muscle function. *J Bone Joint Surg Am.* 1995;77:1510-1519.
- Morelli V, Smith V. Groin injuries in athletes. *Am Fam Physician.* 2001;64:1405-1414.
- Morelli V, Weaver V. Groin injuries and groin pain in athletes: part 1. *Prim Care.* 2005;32:163-183.
- Nelson EN, Kassarian A, Palmer WE. MR imaging of sports-related groin pain. *Magn Reson Imaging Clin N Am.* 2005;13:727-742.
- Pomeranz SJ, Heidt RS Jr. MR imaging in the prognostication of hamstring injury. Work in progress. *Radiology.* 1993;189:897-900.
- Renstrom PA. Tendon and muscle injuries in the groin area. *Clin Sports Med.* 1992;11:815-831.
- Renstrom P, Peterson L. Groin injuries in athletes. *Br J Sports Med.* 1980;14:30-36.
- Rizio L 3rd, Salvo JP, Schurhoff MR, Uribe JW. Adductor longus rupture in professional football players: acute repair with suture anchors: a report of 2 cases. *Am J Sports Med.* 2004;32:243-245.
- Robinson P, Barron DA, Parsons W, Grainger AJ, Schilders EM, O'Connor PJ. Adductor-related groin pain in athletes: correlation of MR imaging with clinical findings. *Skeletal Radiol.* 2004;33:451-457.
- Slavotinek JP, Verrall GM, Fon GT. Hamstring injury in athletes: using MR imaging measurements to compare extent of muscle injury with amount of time lost from competition. *AJR Am J Roentgenol.* 2002;179:1621-1628.
- Speer KP, Lohnes J, Garrett WE Jr. Radiographic imaging of muscle strain injury. *Am J Sports Med.* 1993;21: 89-95; discussion 96.
- Tuite DJ, Finegan PJ, Saliaris AP, Renstrom PA, Donne B, O'Brien M. Anatomy of the proximal musculotendinous junction of the adductor longus muscle. *Knee Surg Sports Traumatol Arthrosc.* 1998;6:134-137.