The Quantitative Anatomy of the Hip Capsular Ligaments and Insertional Footprints

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Introduction

Over the past decade there has been a dramatic worldwide increase in the number of hip arthroscopy procedures performed and indications continue to evolve. Traumatic and atraumatic hip instability is being increasingly recognized as a source of hip disability; more and more these patients are being managed arthroscopically. Further, partial capsulectomies and capsulotomies are routinely performed as part of the arthroscopic procedure. These capsuloligamentous incisions are often left unrepaired. There is concern that these capsulotomies and partial capsulectomies may create the potential for complications, including recently reported cases of post-operative hip instability. Understanding the anatomy may prove to be important in planning for reparative and/or reconstructive techniques.

While the qualitative and quantitative insertional anatomy of the major ligaments about other large joints, such as the knee and shoulder have been described, to date the precise anatomy and quantitative anatomic descriptions of the hip capsular ligament insertional footprints have not been reported. Furthermore, in the last few decades only two studies have specifically addressed the macroscopic anatomy of the hip capsular ligaments. Unfortunately, there are many inconsistencies in the reported macroscopic anatomy of the capsular ligaments and no study published to date addresses the ligamentous insertional footprints. The iliofemoral ligament (ILFL) has been reported to have two or three distinct bands and the ischiofemoral ligament (ISFL) has been reported to have two or three bands, the ischiofemoral ligament (ISFL) has been reported to have one, two or even three bands and it is unclear whether the pubofemoral ligament (PFL) terminates by blending with the capsule and ISFL, or inserts directly on the femoral neck. This study was performed to quantitatively assess the ligaments and their insertional footprints.

Methods

Anatomical measurements of the three main hip capsuloligamentous structures and their insertions were made using a three-dimensional digitalizing system (Revware Microscribe, Revware, Inc., Raleigh, NC) in 8 paired fresh-frozen cadaveric hips (mean age = 73±10.7 years, range 61-88 years, two male and two female specimens) without evidence of previous surgery. The three-dimensional coordinate points recorded by the Microscribe were imported into the commercially available non-uniform rational basis spline (NURBS) modeling program Rhinoceros (McNeel North America, Seattle, WA) and computer models were generated to determine the mean areas and dimensions of the ligaments and footprints as well as their relative position to bony prominences about the hip. Coordinate points were also collected from the acetabulum and proximal femur and imported into Rhinoceros; three-dimensional models of the hip joint were made to pictorially demonstrate the anatomic relationships. The quantitative information measured in Rhinoceros was recorded in Microsoft Excel (Microsoft Corporation, Redmond, WA) for statistical analysis. The mean, median, standard deviation and range were calculated for all ligament and footprint areas, lengths and distances between structures and osseous landmarks.

Results

The ILFL has a mean area of 34.6±11.7cm² and distally branches into two distinct arms, the medial and lateral ILFL (Figure 1). The single proximal attachment is 2.9±1.8mm from the acetabular rim, the mean area is 4.2±1.5cm². The mean areas of the ILFL medial and lateral arm attachments along the intertrochanteric line are 4.8±2.0cm² and 3.1±1.5cm², respectively. The PFL originates from a small proximal attachment on the iliopectinal eminence with a mean area of 1.4±0.6cm², 2.1±1.4mm from the acetabular rim. The PFL blends with the medial arm of the ILFL anteriorly before curving inferoposteriorly around the femoral head to blend with the ISFL distally; it does not have a femoral insertion. The mean area of the whole PFL is 13.0±4.3cm². The ISFL is a single band with an area of 18.4±3.6cm². It has a large proximal attachment posteriorly, 2.4±1.7mm from the acetabular rim, with an area of 6.4±2.0cm². The small distal attachment superiorly at the base of the greater trochanter has an area of 1.2±0.3cm², it does not blend with the ILFL lateral footprint on the superior femoral neck.

Discussion

In recent years there has been a significant increase in interest in the evaluation and treatment of the non-arthritic hip. As a consequence the number of hip arthroscopy procedures performed annually is on the rise, the ability to diagnose intra-articular hip pathology is constantly improving with enhanced imaging modalities and increasing physician experience, and there is a need for concrete understanding of the hip capsular ligaments. This is the first study to date which quantifies, to a high degree of precision, the insertional anatomy and relationships to pertinent landmarks of the hip ligaments and their insertional footprints.

In agreement with most other authors, the ILFL consists of two distinct bands and the ISFL comprises of a single cohesive band. The PFL blends proximally with the medial border of the ILFL anteriorly and courses inferoposteriorly like a sling around the head of the femur – a finding reported only once before. Distally the PFL terminates by blending with the proximal aspect of the ISFL, near the acetabular rim, and does not have a femoral attachment. Therefore the PFL is an unusual ligament because it inserts onto hip capsule rather than to bone.

Figure 1. Computer model of the hip capsular ligament (A) insertional footprints (B) and whole ligaments demonstrating the ligamentous anatomy of the anterior hip. The PFL can be seen blending with the ILFL anteriorly. The ILFL, iliofemoral ligament; PFL, pubofemoral ligament; ISFL, ischiofemoral ligament; IL-P, ILFL proximal; P-P, PFL proximal; IS-P, ISFL proximal; IL-D, ILFL distal medial; IL-DL, ILFL distal lateral; IS-D, ISFL distal.

The insertional footprints of the ILFL, PFL and ISFL on the proximal femur and acetabular region of the pelvis can be described in a reproducible way relative to the osseous landmarks of the hip. The shape and relative locations of the insertional footprints and whole ligaments are consistent across all eight specimens. This is the first study to quantify the insertional footprints and whole ligament areas and dimensions. Appropriate surgical concepts for treating traumatic and atraumatic hip pathology require a precise knowledge of the native hip capsuloligamentous anatomy. Quantification of these ligaments and their insertional footprints will help clinicians develop better techniques to clinically evaluate laxity of the hip, as well as develop open and/or arthroscopic procedures to address hip instability and capsular laxity. Additionally, accurate quantitative descriptions of the hip capsular ligaments may help with the design of biomechanical models and studies in the future.

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