Anatomic Mapping for Surgical Reconstruction of the Proximal Tibiofibular Ligaments

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**abstract**

Injury to the proximal tibiofibular joint is uncommon. Previous studies regarding the anatomy of this region have predominantly focused on joint orientation. As radiographic technology has advanced, later studies have attempted to evaluate the capsular anatomy. However, no reports specifically map the ligaments to this joint. The objectives of the current study were to define specific ligamentous structures that provide stability to the proximal tibiofibular joint, describe easily identifiable and reproducible surgical landmarks to aid in surgical reconstruction, and add to the understanding of the posterolateral structures of the knee previously described by other authors.

The proximal tibiofibular joint ligaments were identified in 10 fresh-frozen cadaveric specimens. Average ligament length, width, and thickness and area of the footprints of the tibial and fibular attachments were measured. Distances from the ligament footprints to known anatomic landmarks (eg, Gerdy’s tubercle, tibial articular surface, and fibular styloid) were also measured. The anterior ligament tibial attachment was a mean of 15.6 mm lateral and posterior to Gerdy’s tubercle and 17.3 mm anterior and inferior from the fibular styloid. Posterior ligament tibial insertion was a mean of 15.7 mm inferior to the tibial articular surface on the tibial side and 14.2 mm medial and slightly inferior from the fibular styloid.

Definable ligaments provide stability to the proximal tibiofibular joint and can be reconstructed in an anatomic fashion using the landmarks and parameters described. This information allows for an anatomic reconstruction of the proximal tibiofibular joint, which should provide patients with better outcomes and fewer postoperative sequelae.

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**Figure:** Intraoperative photograph showing an anatomic reconstruction of the proximal tibiofibular joint ligaments with an autograft gracilis tendon through bone tunnels in the proximal tibia and fibula.
Injuries to the proximal tibiofibular joint are rare but occur as a result of noncontact twisting movements in athletes or as a result of direct trauma. Stability of the lateral aspect of the knee may be compromised with dislocation of proximal tibiofibular joint due to attachment of the lateral collateral ligament and biceps femoris tendon on the proximal fibula. According to Basmajian, the proximal tibiofibular joint may be regarded as an accommodatory joint, designed to give a little play to the fibula to protect it from breaking. Treatment of the acutely dislocated proximal tibiofibular joint consists of closed reduction, cast or functional brace immobilization for 4 to 6 weeks, and rehabilitation with gradual return to activity as symptoms allow. Some studies report that an acute injury can take up to 10 months to completely resolve. Those that go on to develop chronic instability can be treated with another period of immobilization. However, chronic subluxation or dislocation has been linked to peroneal nerve injury and activity limiting pain. For these patients, surgical stabilization is indicated.

Until recently, surgical treatment focused on either arthrodesis or fibular head resection. Patients treated with arthrodesis are at risk of developing ankle pain secondary to the limitation of rotation and proximal translation inherent to the fibula. When postarthrodesis pain develops, patients may be treated with resection of the fibular head or fibular osteotomy to restore that lost motion. Resection of the fibular head is contraindicated in athletes due to the possibility of disruption of the posterolateral corner structures.

With a re-emerging trend toward anatomic reconstruction of other ligaments of the knee (eg, anterior and posterior cruciate ligaments and posterolateral corner), complications such as stiffness, pain, and instability related to fibular head arthrodesis or resection can be avoided by adopting a similar pattern of treatment for the proximal tibiofibular joint. Proper identification of these ligamentous attachments also aids in preventing iatrogenic injury to the peroneal nerve, which lies approximately 2 cm distal to the fibular styloid. The noted complications of surgical treatment were motivating factors in the current study. The authors’ intention of obtaining accurate anatomic footprint measurements was to allow surgeons to better plan a ligamentous reconstruction of the proximal tibiofibular joint to avoid the need for arthrodesis or fibular head resection with the resulting outcomes previously mentioned. LaPrade et al noted that with disruption of ligaments of the posterolateral corner, it was difficult to identify the anatomic insertion, especially with chronic ruptures or severe injuries. Knowing the anatomic dimensions of the proximal tibiofibular joint ligaments will allow more accurate placement of bone tunnels, and fixation of graft material will be more anatomic.

The primary goal of this study was to define the ligaments that provide stability to the proximal tibiofibular joint. An objective of the study was also to identify the insertions of these ligaments in relation to easily identifiable and reproducible landmarks about the knee because a clear definition of these structures and their attachment sites will allow for the development of an anatomic reconstruction technique. Another objective was to add further detail regarding the structures of the posterolateral corner of the knee previously described by LaPrade et al.

**Materials and Methods**

Ten fresh-frozen cadaveric knees were used for dissection. All specimens were inspected before dissection to confirm that no prior surgical procedure had disrupted the anatomy in question. All subcutaneous tissue, fascia, and muscle were removed 10 cm proximal and distal to the area in question, exposing the underlying bone and ligaments. Before removing the muscular tissue, the biceps femoris tendon, popliteus tendon, insertion of the iliotibial band at Gerdy’s tubercle, and lateral collateral ligament were identified. The identification of these known landmarks served as reference points for the origin and insertion of each ligament. The fibula was cut below the neck to allow mobilization of the proximal fibula and better assessment of the ligaments near the articular surface. One author (A.S.) made all ligament measurements using a digital caliper accurate to 0.01 mm. Each ligament was measured twice to confirm accuracy of measurement.

After identifying the area of interest via dissection at the proximal tibiofibular joint, clear thickenings of the anterior and posterior capsules were found that were consistent with ligaments. To better delineate these structures, the fibular head was translated anterior and posterior, marking note of the portions of the capsule providing restraint to further movement and areas that did not retract on translation. The capsular tissue and intra-articular fat were removed from around the thickenings. After removing the capsular tissue, the thickening was meticulously cleaned to confirm that they had fibers that appeared consistent with ligaments. The ligaments were labeled based on whether they were anterior or posterior to the fibular styloid.

All lengths were measured from the most proximal to most distal portion of identifiable fibers. Width and thickness were quantified at midsubstance of the ligament for all specimens. The footprint measurements were determined by sectioning the ligaments, using a clamp to pull the ligament up, and measuring the footprint from the superior and inferior portion of the distal insertion and the proximal origin. The length and width were obtained to establish the area of the footprint. This was performed for the fibular and tibial components of each ligament. In the case of a specimen having a split anterior ligament, both were measured as described.

All reference measures to known landmarks were from the center of the at-
A measurement was performed from the center of the tibial attachment of the anterior ligament to the center of Gerdy’s tubercle for the anterior ligaments. Another measurement of the length from the center of the fibular attachment of the tendon to the most prominent portion of the fibular styloid was performed. The posterior structures were measured in a similar manner. The joint space measurement was obtained by measuring the superior ligament midsubstance to the articular cartilage, which was directly superior to the center of the proximal footprint of the ligament. The posterior ligament to fibular styloid measurement was obtained in a manner similar to that in the anterior structures. Each ligament required careful dissection due to an intimate association with surrounding structures, namely the biceps femoris with the anterior ligament and the popliteus muscle with the posterior band.

**RESULTS**

An anterior ligament complex and posterior proximal tibiofibular ligament were identified in all 10 specimens. The posterior ligament consisted of a single bundle in all specimens. However, the anterior ligament had a single bundle in 7 of the 10 specimens and a bifid, or double-bundle, configuration in the remaining 3 (Figure 1). The measurement results were separated within the anterior ligament group to show the dimensions of the anterior superior and anterior inferior bundles (Table).

The attachment of the anterior band (Figure 2) to the tibia was found a mean of 16.4 mm posterior to Gerdy’s tubercle with a mean attachment area of 7.5 mm². Its course was in a linear fashion posterior to anterior with little variation among specimens. The fibular attachment had a mean distance 17.3 mm anteroinferior from the fibular styloid and a mean footprint area of 8.4 mm². The fibular footprint was immediately anterior to the insertion of the biceps femoris. The posterior ligament tibial footprint (Figure 3) was

### Table

**Proximal Tibiofibular Ligament Measurements**

<table>
<thead>
<tr>
<th>Ligament</th>
<th>Dimension</th>
<th>Avg Measurement (Range), mm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anterior, n=7</strong></td>
<td>Length</td>
<td>15.6 (14.6-16.4)</td>
</tr>
<tr>
<td></td>
<td>Width</td>
<td>9.0 (6.6-12.0)</td>
</tr>
<tr>
<td></td>
<td>Thickness</td>
<td>2.8 (2.2-3.4)</td>
</tr>
<tr>
<td></td>
<td>Gurdy’s distance</td>
<td>16.4 (15.3-18.2)</td>
</tr>
<tr>
<td></td>
<td>Styloid distance</td>
<td>17.32 (14.3-20.6)</td>
</tr>
<tr>
<td></td>
<td>Tibial footprint area, mm²</td>
<td>7.5 (6.3-9.3)</td>
</tr>
<tr>
<td></td>
<td>Fibular footprint area, mm²</td>
<td>8.4 (6.5-9.5)</td>
</tr>
<tr>
<td><strong>Anterior variant, n=3</strong></td>
<td>Length</td>
<td>15.9 (15.0-16.7)</td>
</tr>
<tr>
<td></td>
<td>Width</td>
<td>7.9 (6.6-9.9)</td>
</tr>
<tr>
<td><strong>Anterosuperior</strong></td>
<td>Thickness</td>
<td>2.5 (2.4-2.5)</td>
</tr>
<tr>
<td></td>
<td>Gurdy’s distance</td>
<td>16.1 (15.4-16.8)</td>
</tr>
<tr>
<td></td>
<td>Styloid distance</td>
<td>16.4 (15.9-17.1)</td>
</tr>
<tr>
<td></td>
<td>Tibial footprint area, mm²</td>
<td>7.7 (7.2-8.0)</td>
</tr>
<tr>
<td></td>
<td>Fibular footprint area, mm²</td>
<td>7.5 (6.5-8.0)</td>
</tr>
<tr>
<td><strong>Anteroinferior</strong></td>
<td>Length</td>
<td>14.2 (13.5-14.7)</td>
</tr>
<tr>
<td></td>
<td>Width</td>
<td>5.1 (4.7-5.4)</td>
</tr>
<tr>
<td></td>
<td>Thickness</td>
<td>2.3 (1.9-2.7)</td>
</tr>
<tr>
<td></td>
<td>Gurdy’s distance</td>
<td>13.7 (12.5-15.2)</td>
</tr>
<tr>
<td></td>
<td>Styloid distance</td>
<td>22.7 (20.2-26.1)</td>
</tr>
<tr>
<td></td>
<td>Tibial footprint area, mm²</td>
<td>4.9 (4.4-5.3)</td>
</tr>
<tr>
<td></td>
<td>Fibular footprint area, mm²</td>
<td>3.7 (3.1-4.1)</td>
</tr>
<tr>
<td><strong>Posterior, n=10</strong></td>
<td>Length</td>
<td>14.0 (12.6-15.3)</td>
</tr>
<tr>
<td></td>
<td>Width</td>
<td>9.2 (7.2-11.2)</td>
</tr>
<tr>
<td></td>
<td>Thickness</td>
<td>3.1 (2.4-3.4)</td>
</tr>
<tr>
<td></td>
<td>Styloid distance</td>
<td>14.2 (10.7-15.7)</td>
</tr>
<tr>
<td></td>
<td>Joint space distance</td>
<td>15.7 (13.3-17.7)</td>
</tr>
<tr>
<td></td>
<td>Tibial footprint area, mm²</td>
<td>9.3 (7.2-13.4)</td>
</tr>
<tr>
<td></td>
<td>Fibular footprint area, mm²</td>
<td>10.7 (6.7-13.4)</td>
</tr>
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</table>
best located a mean of 15.7 mm directly inferior to the lateral joint space and had a mean attachment area of 9.3 mm². The fibular footprint was positioned a mean of 14.2 mm from the fibular styloid and had a mean footprint area of 10.7 mm². The ligament orientation was linear with minimal obliquity either superior or inferior. The fibular footprint was reliably posterior to the insertion of the biceps femoris (Figure 4).

**Discussion**

Numerous case reports describe instability of the proximal tibiofibular joint. Other studies describe specific techniques for ligamentous reconstruction of the proximal tibiofibular joint. However, none of these reports provide detail regarding the anatomic location of the ligaments in association with known surrounding structures. The purpose of the current study was to identify and define the ligaments that provide stability to the proximal tibiofibular joint and provide measurements from these ligaments to known anatomic landmarks to guide surgeons during anatomic reconstruction.

The study also provides further anatomic detail of the posterolateral corner structures of the knee despite previous well-described reports. Kaplan and LaPrade et al provided some of the earliest and most detailed studies regarding the posterolateral structures of the knee. LaPrade et al not only reported on the individual structures that compose the posterolateral corner but also measured the ligament and tendon attachments and the distances from reproducible bony landmarks to those ligaments. However, neither of their studies discussed the ligaments to the proximal tibiofibular joint. Parkes and Zelko reported an anterior review of separate and distinct ligaments to the proximal tibiofibular joint and that the anterior ligament comprised 3 separate bands extending from the fibular head to the lateral tibial condyle; the posterior ligament was reported to be a mere capsular thickening. Ward and Eckardt later performed a more detailed dissection of the area on 2 cadaver specimens, focusing only on the anterior aspect of the joint; they found that the proximal leg anterior compartment fascia blends into the bone to become the ligament. Bozkurt et al expanded on these data and dissected 14 knees. They reported that in more than half of their specimens, the anterior ligament was fused to the biceps femoris tendon and only separately identifiable when a communication existed between the proximal tibiofibular joint and knee joints. They also showed the presence of a posterior ligament but provided little detail beyond its presence. In a magnetic resonance arthrography study, Dirim et al reported the posterior ligament in slightly more detail while examining the communication between the knee joint and the proximal tibiofibular joint.

The current authors were able to identify the anterior and posterior ligaments in all specimens. The anterior ligament was intimately associated with the biceps femoris tendon near its insertion on the lateral tibial condyle. However, this association was not so involved as to prevent isolation of the ligament. Comparable with the studies of Parkes et al and others, the current authors found 2 separate bands, or
bundles, composing the anterior ligament 30% of the time. However, no more than 2 bundles were found, nor did this variant appear to make the joint more or less stable with translation. The posterior ligament was always well defined and more robust than a simple capsular thickening. Dissection showed the anterior ligament could be reliably located a mean of 17 mm from the fibular styloid for the fibular insertion and a mean of 16 mm from Gerdy’s tubercle for the tibial insertion. The posterior ligament insertion was a mean of 14 mm posterior and inferior to the fibular styloid and a mean of 16 mm inferior to the lateral tibial articular surface.

Ferretti et al9 and LaPrade et al10,12,40 reintroduced the concept of anatomic reconstruction of the major knee ligaments, reporting improved biomechanical and clinical outcomes when compared with less anatomic techniques. Conservative treatment (ie, rest, immobilization, and rehabilitation) of an unstable proximal tibiofibular joint is typically used for 6 months to 1 year or until patients can no longer tolerate the associated symptoms. When these measures fail, patients may be treated with pin or screw fixation of the proximal tibiofibular joint, arthrodesis, or fibular head resection. However, these procedures can result in hardware migration or breakage, chronic ankle pain secondary stiffness with a loss of normal fibular rotation, or chronic knee pain and instability due to the loss of ligamentous and muscular insertion to the lateral aspect of the knee. More recently, authors have advocated a ligamentous reconstruction of the proximal tibiofibular joint to avoid these potential complications. Luscombe and Maffulli41 and Maffulli et al42 described a technique using a gracilis tendon where 2 tunnels are placed laterally through the proximal fibula, across the proximal tibiofibular joint, and into the tibia with the graft secured on the medial aspect of the tibia. Other techniques involve using 1 or 2 slips of the biceps femoris tendon through tibial bone tunnels to reconstruct the posterior ligament or both.41 More recently, with the movement toward anatomic reconstruction, Dawson and Bear29 and Horst and LaPrade44 reported a closer-to-anatomic technique using gracilis tendon. However, none of these reports provide specific measurements or landmarks to guide surgeons during reconstruction of the proximal tibiofibular joint as the current study does.

Due to success, LaPrade et al10 championed a 2-tunnel technique for reconstructing the posterolateral corner. This technique is theoretically beneficial secondary to reconstructing the popliteofibular ligament.19 During the course of the dissections in the current study, it was observed that this technique does not truly reconstruct the popliteofibular ligament by passing the graft posteriorly from the fibula to the tibia. Instead, this sequence of graft passage reconstructs the posterior tibiofibular ligament. Surgeons should be aware of this variation if they choose to use this 2-tunnel technique.

This study had limitations. The sample size was small (10 knees). Although this is comparable with previous dissection studies focusing on the proximal tibiofibular joint, the use of additional specimens can help improve the accuracy of the measurements, accounting for variations in patient size. However, funding limited the authors’ ability to secure more specimens. Also, measurements were performed twice by only 1 author. Intra- and interobserver reliability would have been enhanced by having the other authors perform measurements, thus providing a greater number of measurements and further increasing the accuracy of the data reported.

CONCLUSION

This study defined the anatomy of the proximal tibiofibular joint to allow for the development of a reproducible anatomic reconstruction technique. The ligaments of the proximal tibiofibular joint are distinct structures that can be located in relation to the fibular styloid, Gerdy’s tubercle, and the tibial articular surface. The proximal tibiofibular joint ligaments serve important biomechanical and anatomic functions. Being able to reliably identify the insertion points of these ligaments and knowing the dimensions of the footprints will help guide surgeons in performing anatomic reconstruction of these structures.

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