Proximal Tibiofibular Syndesmotic Disruptions in Sport

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Abstract
The proximal tibiofibular joint (PTFJ) is a highly stabilized ligamentous arthroidal synovial joint, creating a continuum between the knee and ankle motion unit. PTFJ instability is a rare pathologic entity which is a commonly overlooked diagnosis, especially in the setting of high-energy trauma. The most common Ogden-type dislocation is anterolateral; other types are associated with a high incidence of common peroneal nerve injury. Patients may present with complaints of pain rather than instability. Although soft tissue reconstruction of the joint can be considered especially in athletic young patients, arthrodesis can be another potential treatment option, especially for chronic instability, posttraumatic arthrosis, or failed prior surgery.

Overview

Proximal tibiofibular joint (PTFJ) dislocation is an extremely uncommon injury, which may be easily missed during the initial assessment and on plain radiographs (Ellis 2003; Laing et al. 2003). The PTFJ is a stable joint, due to its strong ligamentous support (Levy et al. 2006). Although the most common PTFJ injury mechanism is usually hyperflexion of the knee with an inverted and extended foot (Ogden 1974b; Falkenberg and Nygaard 1983), resulting in the anterior dislocation of the fibular head, other mechanisms exist

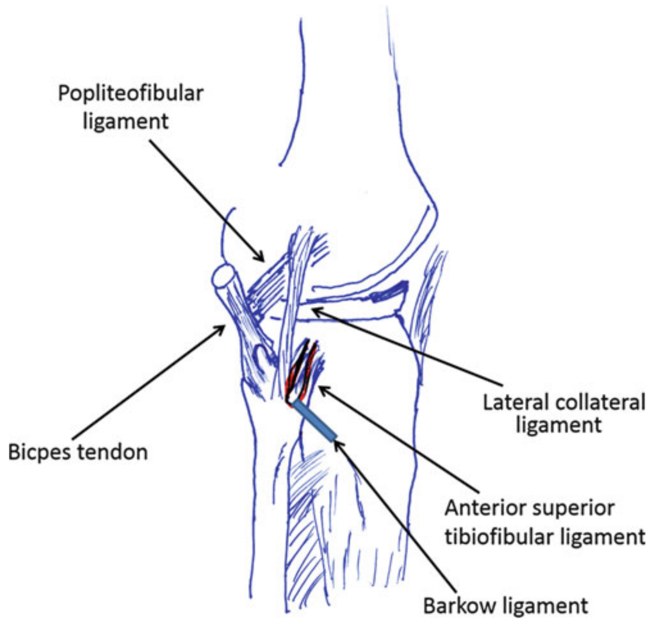

Fig. 1 Schematic drawing of the right knee illustrating the Ligamentous attachment around the PTFJ the bold line represent the ligament of Barkow

involving high injury trauma. The following chapter will discuss the anatomy, joint biomechanics, injury mechanisms, and treatment options.

Anatomy

Bony anatomy of the fibula: The fibula is attached to the tibia by the capsule of the superior tibiofibular articulation and an interosseous membrane that pass obliquely to blend with the inferior syndesmosis. The latter is comprised of the anterior and posterior tibiofibular ligament and the interosseous ligament.

The proximal fibula lies posterior to the central weight-bearing portion of the lateral tibial condyle, and the upper head (***capitulum fibulæ***) is a quadrilateral surface projecting upward, forward, and medially. The styloid process is the most proximal part of the fibular head and serves for the attachment of the popliteofibular ligament (Brinkman et al. 2005; Fig. 1). The cross-sectional diameter of the fibula is triangular in the upper, trapezoidal in the middle, and elliptical at the lower part of the bone (Brinkman et al. 2005).

Muscular and ligamentous attachments: The long head of the biceps divides distally into a direct arm that inserts into the posterolateral edge of the fibular head, and an anterior arm crossing lateral to the fibular collateral ligament, and separated by a bursa, on its way to attach to the lateral edge of the fibular head (Terry and LaPrade 1996b; Fig. 1).

The short head of the biceps divides into six insertions distally (Terry and LaPrade 1996b), of which only the direct arm is attached to the superior edge of the fibular head, posterior and lateral to the styloid process and posterior and medial to the fibular collateral ligament (Terry and LaPrade 1996b).

The fibular collateral ligament originates as a fan-shaped structure from the lateral femoral epicondyle and supracondylar ridge of the femur. It then runs distally where its medial fibers attach the lateral fibular edge and the medial fibers continue distally and blend with the superficial fascia of the peroneal compartment (Fig. 1).

Other ligamentous attachments include the fabellofibular ligament, the popliteofibular ligament, and the popliteus muscle which inserts onto the styloid process of the proximal fibula (Terry and LaPrade 1996a, b).

Proximal tibiofibular joint (PTFJ): The proximal tibiofibular joint is a small gliding synovial joint. It has several biomechanical roles including transmission of about one sixth of the compressive static force applied to the ankle (Lambert 1971). However, it is suggested that the joint functions mainly in the dissipation of the tensile forces generated by the lateral tibial bending moment (Espregueira-Mendes and da Silva 2006). This is supported by some biomechanical evidence demonstrating that the proximal and middle third of the fibula withstand the highest tensile forces other than any other skeletal bone (Evans and Band 1966).

The PTFJ is an arthroidal sliding synovial joint covered by hyaline cartilage formed of fibular facet of different shapes overhanging the corresponding facet in the posterolateral edge of the lateral tibial condyle. Different shapes of the articular facets have been described including planar, trichoid, double trichoid, condylar, trochlear, ball and socket, and saddle (Eichenblat and Nathan 1983; Bozkurt et al. 2003; Espregueira-Mendes and da Silva 2006; Fig. 2).

The articular inclination ranges from 5 to 80° (Ogden 1974a; Falkenberg and Nygaard 1983; Ellis 2003; Laing et al. 2003); the horizontal is more common than oblique inclination and is associated with increased articular surface area and rotator mobility. The contour of the articular facets is elliptical, circular, and triangular, and there is no clear relationship between the facet shape and development of early osteoarthritis although osteoarthritic changes have been reported in the oblique–trichoid shape (Espregueira-Mendes and da Silva 2006).

The capsule of the joint is thickened anteriorly, invaginating into the joint, separated from each bone by fat pad lined with a synovial membrane; in 10 % of the cases, it is continuous with the synovial membrane of the knee joint (Lambert 1971; Espregueira-Mendes and da Silva 2006).

The ligamentous stabilization of the joint is provided mainly by the anterior and posterior tibiofibular ligaments, representing thickenings of the joint capsule (Laing et al. 2003), and the ligament of Barkow (Terry and LaPrade 1996b; Ellis 2003; Laing et al. 2003). The latter was found to be present in about 95 % of the cases, acting in the same manner as the anterior and posterior tibiofibular ligament. Additional stabilization is provided by the fibular collateral ligament and the short and long head of biceps (Figs. 1 and 3).

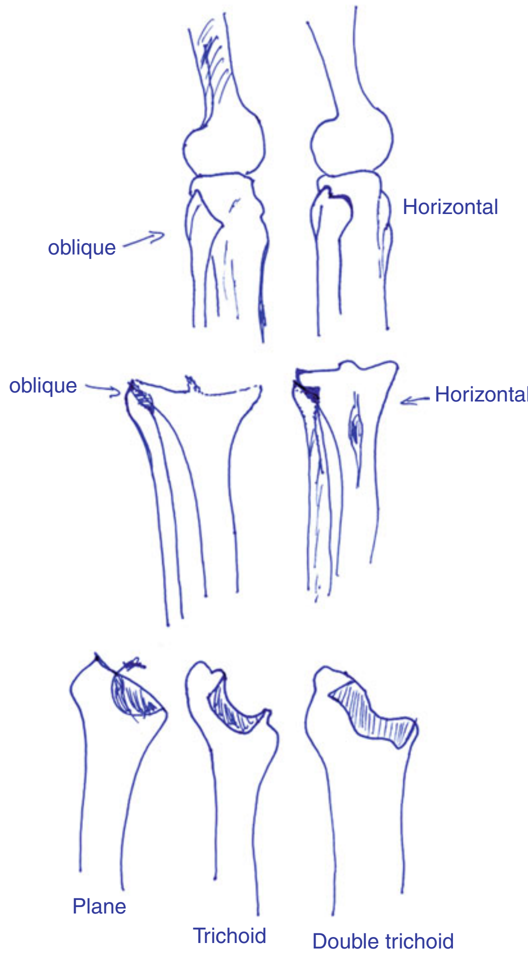

Fig. 2 Different shapes of fibular facet including oblique, horizontal. In the inferior panel planar trichoid and double trichoid shapes

Neurovascular structures: The peroneal artery originates from the tibial artery in most of the cases. However, in 5 % of the cases, it originates directly from the popliteal artery. The distance from the fibular head to the peroneal artery origin ranges from 3.5 to 9.5 mm (Brinkman et al. 2005). The common peroneal nerve arises from the sciatic nerve at the level of popliteal fossa. It travels distally and laterally traverses the interval between the short head of the biceps femoris muscle posteriorly and the lateral head of the gastrocnemius muscle anteriorly. It then hooks around the fibular head laterally entering the anterolateral

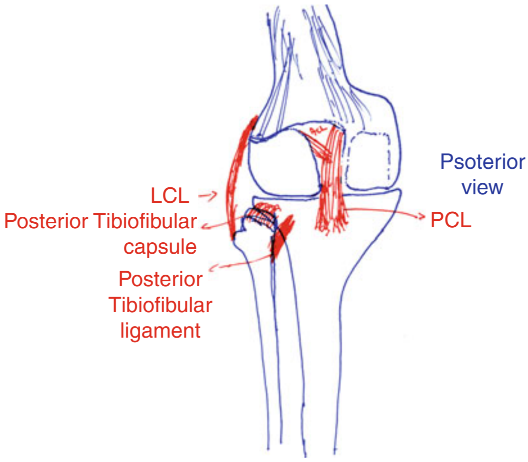

Fig. 3 Posterior view of the proximal tibiofibular joint demonstrates the posterior tibiofibular ligament and capsule

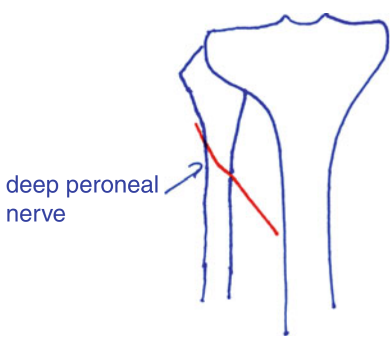

Fig. 4 Schematic anterior view of a right proximal tibiofibular joint. The common peroneal; recurrent anterior branch for the proximal tibiofibular joint, deep and the superficial peroneal nerve.

aspect of the leg deep to the peroneus longus muscle, where the nerve splits into deep and superficial peroneal branches. Clinically the coursing superficially around the fibular head makes the peroneal nerve vulnerable to traumatic injury from proximal tibiofibular joint dislocation, proximal fibular fracture, or compression by the origin of the peroneus longus or ganglion cyst (Spinner et al. 2009; Donovan et al. 2010; Fig. 4).

Joint Biomechanics

The proximal tibiofibular joint and the interosseous membrane are considered as an integral unit of the ankle joint. The major biomechanical function of the fibula is maximizing ankle stability during the different phases of ankle motion. As the ankle joint widens during dorsiflexion, the fibula external rotates, excurse superiorly and bend medially, causing the oblique fibers of the interosseous membrane to become horizontal. The vertical downward movement of the fibula becomes more important during the strike phase of running when the forces applied are three to six times than the body weight, and the above fibular dynamics enables deepening the ankle mortise and converting the compressive forces into tension forces across the interosseous membrane and tibiofibular ligaments, hence providing a shock absorber function (Weinert et al. 1973).

Specifically, the PTFJ externally rotates during dorsiflexion of the ankle (Ogden 1974b; Eichenblat and Nathan 1983; Bozkurt et al. 2003; de Seze et al. 2005) which is more accentuated in horizontal fibular joint's facet variants compared to the oblique variants (Ogden 1974a). These movements enable the dissipation of torsional stresses applied at the ankle joint (Lambert 1971).

However the PTFJ also participates in knee joint biomechanics where the fibular head translates in the anterior-posterior plane as a function of knee flexion (Ogden 1974a; Andersen 1985). As the knee flexes, the proximal fibula moves anteriorly with relative relaxation of the fibular collateral ligament and the biceps femoris while with knee extension, these structures become taut and pull the fibula posteriorly (Ogden 1974a; Andersen 1985). In internal rotation of the knee the tensile forces are transmitted by the fibular collateral ligament to the fibular head causing the posterior translation, while in external rotation the PTFJ motion is directed anteriorly (Scott et al. 2007).

PTFJ Dislocation and Subluxation

Subluxation may be idiopathic or traumatic acute or chronic; while first reported by Nelaton in 1874 (Ogden 1974b; Turco and Spinella 1985; Weinert and Raczka 1986; Harvey and Woods 1992), it is an uncommon problem in orthopedics occurring in <1 % of knee injury cases (Harvey and Woods 1992). Idiopathic subluxation usually is part of a more generalized ligamentous laxity, muscular dystrophy, or Ehlers–Danlos syndrome. It is more common in females and it is usually bilateral. Patients usually have lateral pain that increases with direct pressure over the fibular head, decreasing pain intensity as approaching skeletal maturity (Ogden 1974a; Semonian et al. 1995; Sekiya and Kuhn 2003); however, atraumatic proximal fibular subluxation in otherwise healthy individuals is extremely rare but exists (Klaunick 2010; Morrison et al. 2011).

Mechanism of Injury and Classification

The mechanism of injury results usually from twisting, hyperextension (contact and noncontact), and anterior blow to a flexed knee, or a valgus force on a flexed knee (LaPrade and Terry 1997). Harrisson and Hindenach (1959) described four types of proximal tibiofibular dislocations: anterolateral, posteromedial, superior, and subluxation. Later, in 1974, Ogden (1974b) reviewed the literature and used the same classification on 108 cases (Fig. 4a).

Anterior dislocation: This is the commonest type and usually is the result of an athletic injury (Veth et al. 1981; Harvey and Woods 1992; Fallon et al. 1994). The mechanism is usually hyperflexion injury with an inverted and extended foot creating an anterior and lateral pressure on the fibular head resulting in anterior dislocation (Ogden 1974b; Falkenberg and Nygaard 1983; Fig. 5a).

Posteromedial dislocation: It is usually as a direct blow to the knee forcing the fibular head posteriorly and medial such as in a car bumper injury (Fig. 5b).

Superior dislocation: It is usually associated with tibia shaft fracture, as a result of axial loading, e.g., falling from height (Harrison and Hindenach 1959; Gabrion et al. 2003; Fig. 5c).

Further two types were recognized (Fig. 4b) including:

Posterolateral: It is very rare and may be often overlooked in high-energy trauma (Nikolaides et al. 2007).

Inferior dislocation: The mechanism of inferior proximal tibiofibular dislocation is avulsion of the leg resulting in neurovascular lesions (Gabrion et al. 2003).

Clinical Presentation

Acute dislocation: The clinical presentation of patients with acute dislocations is more variable; typical symptoms include lateral knee swelling and pain with ankle motion, locking episodes, and inability to bear weight (Falkenberg and Nygaard 1983; Thomason and Linson 1986). However, especially for acute PTFJ dislocation, a painful lateral knee mass presents with exacerbation during dorsiflexion and eversion of the foot. An additional physical sign is the tense cord formed by the stretched biceps femoris tendon, providing a useful clue in the diagnosis (Ogden 1974b). Associated injury to the common peroneal nerve is most common with the posteromedial tibiofibular dislocation (Sekiya and Kuhn 2003). However, the functional status of the peroneal nerve should be documented with any type of tibiofibular dislocations.

Chronic dislocation: The differential diagnoses of lateral knee pain and/or instability include a lateral meniscus injury, peroneal nerve entrapment (Donovan et al. 2010; Dong et al. 2012), snapping biceps femoris (Kristensen et al. 1989), and iliotibial band syndrome (Barber and Sutker 1992). Nonspecific clinical symptoms exist that mimic lateral meniscus injury, with complaints of lateral knee popping, clicking, and catching (Turco and Spinella 1985; Thomason and Linson 1986). However, a history of worsening pain with twisting motions further suggests lateral meniscus tears (Owen 1968; Giachino 1986). In suspected chronic PTFJ injuries or patients with atraumatic subluxation, it is vital to examine the presence of increased translation of the fibular head compared with the opposite normal knee. For this purpose, two specific tests exist; the apprehension test is done with the knee flexed to 90° to relax the fibular collateral ligament and biceps femoris; an anterior–posterior translatory force is then applied

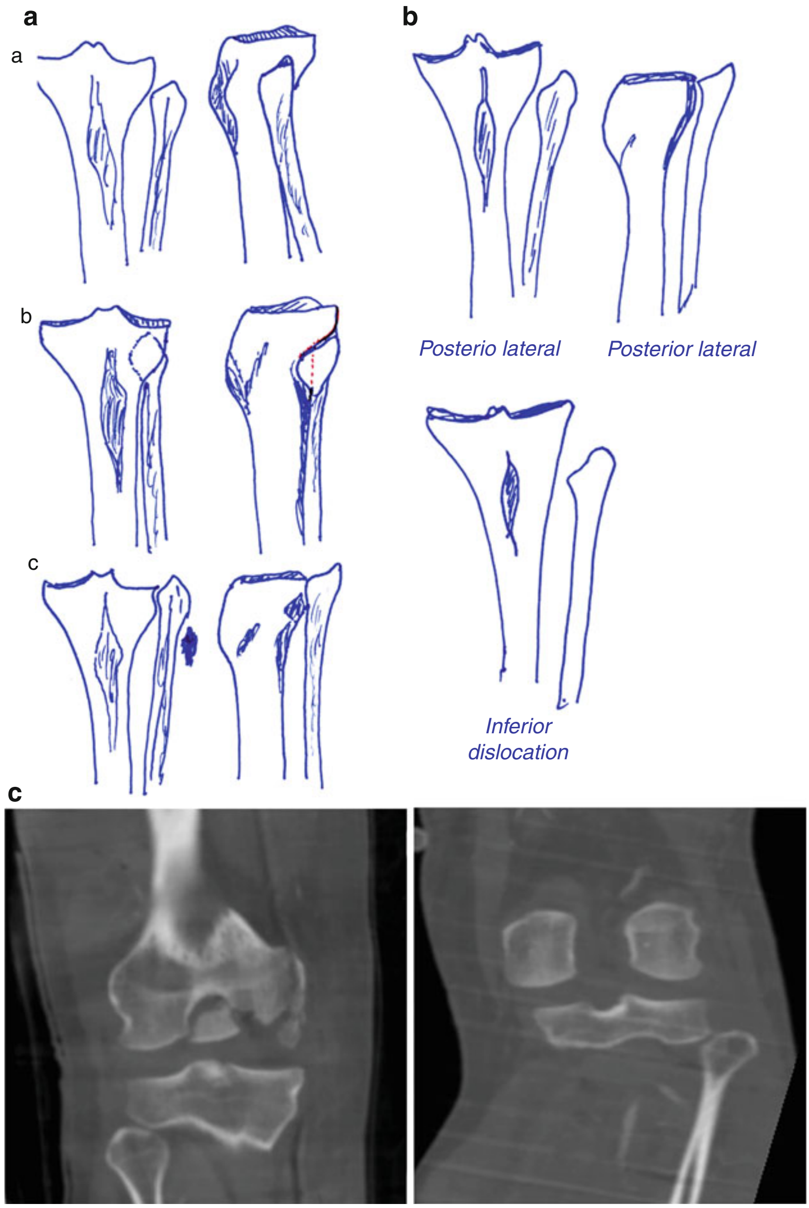

Fig. 5 (**a**) Classification scheme of the proximal tibiofibular joint dislocation according to Ogden. A. Anterolateral dislocation - the The dislocation occurs proceed from lateral to anterior. B. Posteromedial dislocation – the fibula slides posteriorly then medially. C. Superior dislocation - the upward displacement is with associated varying degree of lateralization. (**b**) Two rare dislocation: posterolateral and inferior dislocation of the proximal tibiofibular joint dislocation. (**c**) 53 years old injured during pedestrian motor vehicle accident, suffered from traumatic amputation of the left leg, initial CT demonstrated superior left PTFJ dislocation of the amputated leg as compared to the right PTFJ

to the fibular head while assessing for apprehension and motion (Sijbrandij 1978). The other test is the Radulescu test; since the PTFJ is usually stable with an extended knee, the test is performed in the prone, flexed position. While the knee flexed to 90°, one hand is stabilizing the thigh while internally rotating the leg in an attempt to subluxate or dislocate the fibula anteriorly (Baciu et al. 1974).

Radiographic Evaluation

Radiographic assessment of the PTFJ should include supine and weight-bearing anterior–posterior and lateral radiographs of both the injured and noninjured knees in order to detect changes in the position of the proximal fibula relative to the tibia.

X-ray images of proximal tibiofibular joint should consist of true anterior–posterior and lateral views of both knees (Resnick et al. 1978).

Fig. 6 Resnicks line: Lateral radiograph showing fibular head overlying posterior border of tibia. Increased radiodensity (arrowheads) which identifies most posteromedial portion of lateral tibial condyle, which projected over midportion of fibular head

Resnick et al. defined the most posteromedial portion of the lateral tibial condyle as a radio-dense line on lateral view, at which the middle third of the fibula head should be over this line. With anterolateral dislocation, almost the entire fibular head projects anterior to the Resnick's line, whereas in posteromedial dislocation there is minimal overlap between the proximal tibia and fibula (Fig. 6).

Axial computed tomography is far more accurate than radiographs in establishing the diagnosis (Keogh et al. 1993). MRI is particularly useful for its high-resolution depiction of the soft tissues and changes in the bone such as marrow edema patterns after trauma.

Treatment of Proximal Tibiofibular Instability

Treatment of PTFJ injuries depends on the mechanism of injury, chronicity, and clinical symptoms and associated injuries.

Acute traumatic dislocation: A simple closed reduction may be attempted. In an anterolateral dislocation, the knee is flexed (80–110°) and the foot dorsiflexed and externally rotated, and pressure is applied over the fibular head while the injury mechanism is reversed, until a "pop" is heard. The reduction should be followed by meticulous examination of other associated soft tissue injuries with an emphasis on the common peroneal nerve, fibular collateral ligament, and a complete posterolateral corner injury. Then, cast or brace immobilization should be applied with protected weight bearing followed by full weight bearing for six weeks. In the presence of pain in ankle dorsiflexion and eversion, ankle motion should be restricted (Aladin et al. 2002). Posteromedial and superior dislocations, along with failed closed reduction of anterolateral injuries, are repaired by open reduction and internal fixation (Wheeless 2005 Proximal tibiofibular joint injuries; Original text by Clifford R. Wheeless, III, MD. Last updated by Data Trace Staff on Friday, August 31, 2012 1:23 p.m.).

Surgical treatments include primary repair of the anterior and posterior tibiofibular ligaments, screw fixation, Kirschner-wire fixation, fixation using the TightRope syndesmosis device, and fixation using tendons of the biceps femoris (Miettinen et al. 1999) and gracilis (Sekiya and Kuhn 2003; Horst and LaPrade 2010). Hardware should be removed after 6–12 weeks, similar to a syndesmosis injury of the ankle (Andersen 1985; Turco and Spinella 1985) (Fig. 7).

Atraumatic subluxations: They are usually managed nonoperatively with a supportive strap or bandage placed 1 cm below the fibular head (Hernandez et al. 1996). Physical therapy, nonsteroidal anti-inflammatory medications, and limitation of activities that evoke pain should result in resolution of symptoms.

Chronic dislocations: Treatment options include fibular head resection, partial resection arthroplasty, arthrodesis, soft tissue reconstruction, and midshaft fibular resection.

Fibular head resection: It should be considered in patients with arthritis changes; however, partial resection arthroplasty is biomechanically more preferred although no conclusive evidence on

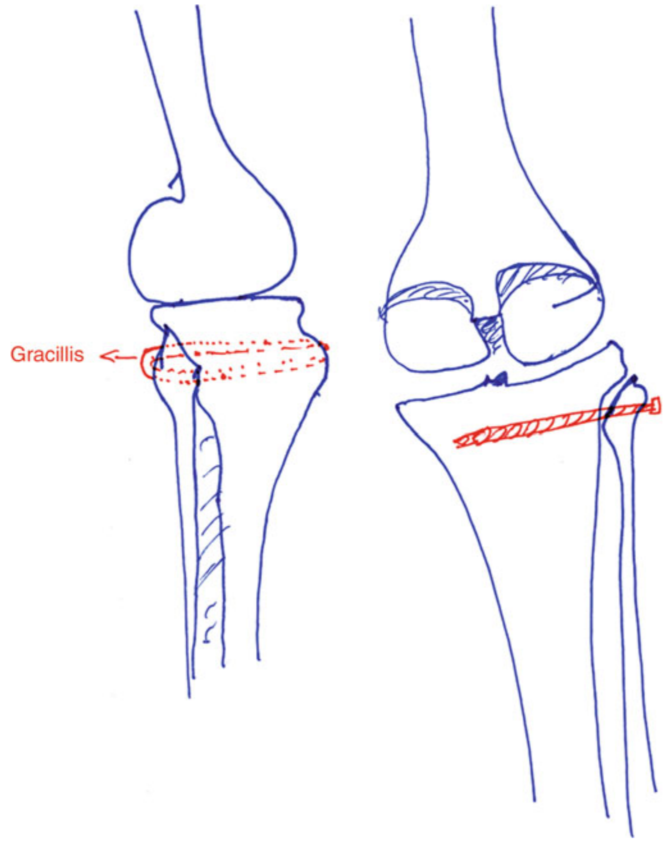

Fig. 7 Schematic view of proximal tibiofibular joint reconstruction using Gracills graft and syndemsotic screw

gait function precludes fibular head resection as good treatment option (Draganich et al. 1991; Agarwal et al. 2012). Complications include chronic knee pain, lateral knee instability, and ankle pain (Draganich et al. 1991; Halbrecht and Jackson 1991) and are contraindicated in athletes (Sekiya and Kuhn 2003).

Arthrodesis

This may be offered as good option for chronic instability in either the presence or absence frank arthritic changes. However, since the proximal fibula externally rotates during dorsiflexion of the ankle (Ogden 1974b; Eichenblat and Nathan 1983; Bozkurt et al. 2003; de Seze et al. 2005) and has motion in both the anterior–posterior direction with knee flexion, increased stress may be transferred to the ankle following PTFJ arthrodesis potentially leading to pain at the ankle (Baciu et al. 1974; Ogden 1974a, b). Uncoupling the proximal fibula and ankle by resecting a small segment of the fibula at the junction of the proximal and middle thirds may prevent the transmission of abnormal stresses to the distal fibula and ankle enabling a more functionally acceptable arthrodesis.

Soft tissue reconstructions using the biceps tendon, deep fascia, iliotibial band, and autogenous semitendinosus tendon with interference screws have also been described and are attempted in traumatic cases especially in younger patients (Horst and LaPrade 2010), However, they are technically demanding and success may be limited in cases where osteoarthritis is already present.

Summary

The proximal tibiofibular joint is a highly stabilized ligamentous arthroidal synovial joint, creating a continuum between the knee and ankle motion unit. PTFJ instability is a rare pathologic entity, which commonly goes with overlooked diagnosis, especially in the setting of high-energy trauma. The most common Ogden-type dislocation is anterolateral; other types are associated with a high incidence of common peroneal nerve injury. Although soft tissue reconstruction of the joint should be considered, especially in athletic young patients, arthrodesis may be an option, especially for chronic instability, posttraumatic arthrosis, or failed prior surgery.

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