Causes, Evaluation, and Treatment of Instability of the Patellofemoral Joint of the Knee: A Review

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Abstract

Instability of the patellofemoral (PF) joint of the knee is typically caused by chronic atraumatic injuries and inciting traumatic events. Anatomically, bony and soft-tissue structures surrounding the PF joint and extensor mechanism contribute to overall stability of the area, which results in efficient kinematic function at the PF articulation. Furthermore, physiological, genetic, anatomical, and demographical factors may affect the development and progression of PF joint instability. Treatment techniques have varied owing to individual factors that may have influence on pathological features of the injury. Nonoperative treatment has predominantly focused on strengthening of the quadriceps and vastus medialis by coordinated, closed chain exercises; if unsuccessful, surgical treatment can be a viable option for chronic dislocation and instability of the PF joint. I reviewed anatomy of the patella and notable bony and soft-tissue constructs; radiographic evaluation and findings suspicious of PF joint instability; and common operative and nonoperative methods for treatment. Despite improved understanding of possible causes and outcomes of treating PF joint instability, further clinical studies are necessary to evaluate the long-term clinical impact of treatment.

Introduction

Instability of the patellofemoral (PF) joint is classically described as the result of chronic atraumatic injuries (eg, anatomical anomalies and ligamentous laxity) or inciting traumatic events. The incidence of a primary dislocation has been reported as 5.8 per 100,000 patients, with a disproportionate occurrence in patients aged 10 to 17 years (incidence, 29 per 100,000). Additionally, women have often been noted with a higher overall incidence of the injury.[1] Recurrent instability has been noted in 17% and 50% of patients with a first-time dislocation and history of subluxation, respectively, which suggests that either may be a strong predictor for future injury.[1]

Most dislocations occur during sports-related activity, commonly after impact that drives the patella out of the trochlear groove, or after an indirect lateral force vector that contracts the quadriceps muscle and thereby the knee experiences a simultaneous valgus stress. After an acute dislocation of the PF joint, time is needed to restore strength and functional range of motion to the knee. In patients with an acute patellar dislocation, significant delay has been reported for return to functional range of motion, quadriceps strength, and sports-related activities.[2]

However, no standard method exists for treatment owing to individual patient characteristics and pathological features of the injury. To help examine long-term effects of treatment, I reviewed the anatomy of the patella and notable bony and soft-tissue structures; radiographic indicators for PF joint instability; and operative and nonoperative methods of treatment.

Anatomy

The triangular-shaped patella is the largest sesamoid bone in the human body and represents a key component of the extensor mechanism. It is an essential element in the biomechanical kinematics that define the extensor mechanism.

Bony Structures

Bony constraints contribute to PF joint stability. The patella is approximately 12 cm^2 in surface area and comprises the medial and lateral facets, which are separated by a vertical ridge. These articulating facets make up the retropatellar surface, which articulates directly with the trochlear groove of the femur.

In a biomechanical study, Goodfellow et al[3] demonstrated that the contact area and zone of articulation changes throughout the arc of motion of the knee joint. As the knee extends from 20° to 90° of flexion, the articulating zone of the patella moves from inferior to superior locations, respectively. Greater than 90° of flexion results in the disengagement of the patella from the trochlear groove, and the area of articulation moves to the peripheral borders of the medial and lateral facets. This articulation is affected by factors such as patella alta, in which the patella does not engage with the trochlear groove until the knee has reached greater degrees of knee flexion. The resulting motion affects the stability and joint-reaction forces at the PF articulation.[4,5]

Soft-Tissue Structures

Soft-tissue structures help ensure efficient kinematic function at the PF articulation. Laterally, three distinct layers of the lateral retinaculum are composed of the lateral restraining structures. Superficially, this layer is confluent with the iliotibial band, with attachments to the quadriceps and patellar tendons. Deep within this layer, the intermediate layer is composed of the lateral PF band, followed by the deepest layer, which is confluent with the joint capsule itself.

The major lateral restraining structures on the medial side of the knee include the medial retinaculum and medial patellar stabilizers. These stabilizers, located in layer two of the three-layer confluence on the medial side of the knee, consist of three medial ligaments.[6] The most notable of which, the medial PF ligament (MPFL), measures about 40 to 50 mm in length. The widest portion remains at the patellar insertion, narrowing to a width of 10 to 20 mm at its attachment to the femur. Additionally, the MPFL fibers have been shown to mesh with those of the vastus medialis obliquus, essentially dynamyzing an otherwise static structure to help guide the patella into the trochlear groove during knee flexion.[7]

In biomechanical and cadaveric studies, the mean tensile strength of the MPFL has been reported at 208 N.[8] Panagiotopoulos et al[7] evaluated 25 fresh-frozen cadaveric specimens and noted that, in the static stabilizers, the MPFL contributed about 53% of the retraining force to lateral patellar subluxation from 0° to 30° of knee flexion, which suggested that the MPFL provides the most substantial static PF joint stabilization.

Radiographic Evaluation

As outlined by Dejour et al,[9] four well-described radiographic factors help categorize and define the potential causes of PF joint instability. Characteristics of trochlear dysplasia, patella alta, and the distance from the tibial tubercle to trochlear groove (TT–TG) may be essential in defining treatment and pathological features of PF joint instability.

Trochlear Dysplasia

Sulcus angle is measured from the highest point of the medial and lateral femoral condyles to the lowest point of the trochlear groove. The average sulcus angle in all patient populations is 138°, with angles greater than 145° indicating trochlear dysplasia. In a study on patient characteristics associated with acute lateral patellar dislocation, Atkin et al[2] found that 28% of symptomatic patients with a primary patellofemoral dislocation exhibited an abnormal sulcus angle greater than 150°. Another method used for identifying trochlear dysplasia involves use of four distinct morphological types, described by Dejour and Le Coultre.[10] Each type allows for general characterization of four distinct anatomic variants that appear to recur frequently when assessing and describing PF joint instability. Although these morphological variants have not shown consistent inter- and intraobserver reproducibility,[11] anatomical variability between individuals may predispose certain patients to an increased risk for PF joint instability.

The identification of trochlear dysplasia is important from risk and natural-history standpoints because of the subsequent effect on PF biomechanics. In their cadaveric study, Van Haver et al[12] simulated the four types of dysplasia in four cadaveric knees and found a significant impact and effect on PF kinematics, contact area, contact pressure, and stability. The results of this study validated predisposing factors that may influence the incidence and progression and contribute to the overall causes of PF joint instability.

Patella Alta

Patella height has been an important radiographic factor in evaluating PF joint instability. Patella alta has frequently been associated with abnormal PF kinematics, increased PF pain and instability, high PF stress, and decreased contact area.[13] Patella height is commonly described by four main indices: the Caton-Deschamps, Blackburne-Peel, Insall-Salvati, and Labelle-Laurin. Studies on each measurement have validated the use of each; however, Caton-Deschamps and Blackburne-Peel indices have been generally regarded as the most reliable and reproducible.[14-16]

Distance from the Tibial Tubercle to Trochlear Groove

Finally, the TT–TG distance has been another radiographic variable that helps describe the characteristics, causes, and treatment of PF instability.[17] Balcarek et al[18] reported that TT–TG distance can be viewed as an independent variable, contributing directly to instability. In general, the mean distance noted in adult populations is about 9 mm (range, 9.4 to 13.6 mm). In their research on TT–TG distance associated with PF joint instability, Caton and Dejour[19] reported 12.7 mm and 19.8 mm in the control and instability groups, respectively. Their results illustrated the cause and effect of TT-TG distance on PF joint instability and the independent contribution of TT–TG distance to the continuum of pathological instability. The threshold for TT–TG distance has been commonly regarded as 20 mm, in which values greater than 20° contribute notably to PF instability. Greater distances may indicate the need for operative treatment.

Treatment

Treatment of PF joint instability has depended on individual patient characteristics that contribute to pathological features of the injury. Several factors and options exist within both operative and nonoperative categories. Nonoperative techniques have been commonly used for treatment after the initial injury.

In a prospective randomized trial[20] and retrospective review,[21] the results of nonoperative and operative methods were compared in treating acute primary patellar dislocations. Both studies found no significant difference in subjective outcomes, recurrent instability, and function or activity scores between the two groups, which reinforced the initial use of nonoperative techniques.

Nonoperative Treatment

Nonoperative treatment has focused on quadriceps and vastus medialis strengthening by coordinated, closed chain exercises. Additionally, the use of bracing has been advocated as an initial modality to help stabilize and prevent recurrent dislocation. Shellock et al[22,23] reported (in two separate studies) on the relative benefits of realignment bracing, with 73% and 76% of patients noted with improvement and correction of lateral subluxation, respectively. However, Muhle et al[24] found no difference with and without bracing in re-establishing lateral patellar tilt angle and displacement using an active motion, kinematic magnetic resonance imaging scanner. Subsequently, uncertainty may exist in using bracing as a standard procedure, with some potential benefit in certain clinical settings such as relatively low risks and contraindications.

Operative Treatment

Surgical procedures have involved treating factors that play a central role in the recurrence of dislocations. The three most commonly addressed components include 1) the trochlear groove, 2) the tibial tubercle and its relationship to the alignment of the PF joint in the axial and sagittal planes, and 3) the restraint associated with the medial soft-tissue structures. Often, it has been helpful to address these components in concert to adequately treat PF joint instability.

Surgical indications for trochleoplasty include patellar instability in trochlear dysplasia, with a sulcus angle greater than 145°, and distinct radiographic patterns. Two main methods involve lateral elevation trochleoplasty and deepening trochleoplasty. In the short term, use of both techniques has shown promising postoperative results.[25,26] In studies on long-term results, however, the findings have been less favorable. One[27] study reported osteoarthritis in 33 of the 34 patients treated with sulcus-deepening trochleoplasties after mean 15-years follow-up. In a similar study, von Knoch et al[28] found that 30% of the patients (n = 38) had patellofemoral degenerative changes in various stages after mean follow-up of 8.3 years. Although use of trochleoplasty may help treat PF joint instability with trochlear dysplasia, alterations in the contact area and pressure about the PF joint may occur, which can result in the onset of arthritis and cartilage damage.

In the presence of increased tibial tubercle offset, patella alta, and altered relationship between the quadriceps and patellar tendons (ie, Q-angle), PF joint stability may be achieved by using distal realignment to simultaneously mitigate the impact of each condition. Possible osteotomies include the Elmslie-Trillat (direct medial translation), Fulkerson (anteriomedial translation), Hauser (posteriomedial translation), and Maquet (direct anterior translation). Use of the Elmslie-Trillat technique has generally been reported with successful results.[28] However, similar to data on patients who underwent trochleoplasty, long-term studies have questioned the sustainability of function.[30-32] In a study with 39 patients, Nakagawa et al[33] noted promising return to function of 91% and 64% at 3.5 and 10 years, respectively, with eventual decline in function and worsening of PF pain and degeneration. Originally described for treating PF pain with articular degeneration to help offload the joint and redistribute contact forces, the Fulkerson osteotomy has since been adopted as a successful distal realignment procedure, in which long-term results have indicated improved function.[34]

Techniques used to treat medial-sided soft-tissue structures include direct repair, imbrication, and reconstruction. In particular, results of MPFL reconstruction have been promising. Long-term follow-up studies on the technique have reported improved functional scores without any subsequent re-dislocation[35] and effective patellar tracking, reduced PF joint pain, and improved apprehension in most patients.[36] Interestingly, use of MPFL reconstruction has been shown to improve PF joint stability despite the presence of other contributing components (ie, trochlear dysplasia or increased TT–TG distance).[37] Additionally, Steiner et al[38] found improve postoperative recurrent dislocation and subluxation rates in patients (n = 34) with untreated trochlear dysplasia.

Although no current consensus exists on type, positioning, and tensioning of potential reconstruction graft,[39] use of MPFL reconstruction has resulted in improved patient outcomes, decreased recurrence of PF joint instability, and possible treatment of other factors associated with PF joint instability.

Conclusion

PF joint instability can have a notable impact on functionality and quality of life of patients. Many factors and anatomical variants contribute to its chronicity and overall impact. Published research has increased substantially in the last several years, resulting in considerable improvements to general knowledge and treatment of the condition. Because PF joint instability results from interrelated factors and conditions, it should not be thought of or treated in isolation to other injuries.

Soft-tissue structures, bony elements, anatomical variants, and demographical factors should be considered when evaluating and treating PF joint instability. In acute conditions, use of nonoperative methods such as physical therapy, quadriceps strengthening, and bracing can improve rehabilitation of patients. However, as acute dislocations transition into chronic and recurrent instability, surgical treatment may become more effective.

The success of certain procedures in treating factors that influence the causes of PF joint instability has become more evident. Distal realignment and MPFL reconstructions can have profound impact on long-term, functional outcomes of the treatment and can re-establish PF kinematics. Our general understanding of PF joint instability and the impact various individualized factors on incidence and prevalence continues to expand, and treatment of PF instability will continue to improve with further clinical research.

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Conflict of Interest

The author reports no conflict of interest.

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