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Insights into Knee Pain: Risk Factors and Management Strategies for Osgood-Schlatter Disease

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ABSTRACT

Introduction: Osgood-Schlatter Disease (OSD) is a common cause of anterior knee pain for children and adults, particularly in those undergoing rapid skeletal growth and participating in high-impact sports. It is characterized by inflammation and microtrauma at the tibial tuberosity due to repetitive stress from the quadriceps muscle,

resulting in pain, swelling, and potential ossicle formation. While OSD is often self-limiting, persistent symptoms can impair physical activity and negatively impact adolescent musculoskeletal development. The exact etiology remains multifactorial, with mechanical overload, anatomical predisposition, and neuromuscular imbalances playing key roles. This study aims to comprehensively analyze the risk factors contributing to OSD and evaluate the effectiveness of various management strategies, including conservative treatment, rehabilitation programs, and surgical intervention for refractory cases.

Materials and Methods: A systematic review of peer-reviewed literature published between 2000 and 2023 was conducted using databases such as PubMed and Scopus. Studies investigating OSD risk factors, pathophysiology, diagnostic methods, and treatment approaches were included. Data were synthesized from clinical trials, cohort studies, and systematic reviews, focusing on mechanical, anatomical, and physiological risk factors. Treatment strategies analyzed included activity modification, knee strengthening programs, pharmacological interventions, and surgical techniques. Special emphasis was placed on the comparative effectiveness of conservative rehabilitation approaches versus surgical management for persistent cases.

Results: The findings highlight that OSD is predominantly associated with repetitive tensile stress on the patellar tendon, exacerbated by quadriceps tightness, hamstring inflexibility, and rapid skeletal growth. High-impact sports such as soccer, basketball, and gymnastics significantly increase the risk of developing OSD, with a greater prevalence in male adolescents due to higher mechanical loading. Anatomical variations, such as increased tibial tuberosity prominence and altered patellar tendon mechanics, further predispose individuals to the condition. Limited ankle dorsiflexion and lower limb misalignment contribute to increased stress on the tibial tuberosity, intensifying symptoms.Conservative treatment remains the first-line approach, with physical therapy focusing on quadriceps and hamstring flexibility, eccentric strengthening, and tendon-loading protocols demonstrating superior long-term outcomes. Activity modification, while beneficial in reducing acute pain, is less effective in preventing recurrence or improving functional recovery. Corticosteroid injections provide temporary symptom relief but are not recommended for routine use due to the risk of tendon atrophy and delayed healing. Surgical intervention, including tibial tubercle excision, is reserved for chronic, refractory cases where ossicle formation leads to persistent pain and functional limitations. Emerging rehabilitation protocols incorporating neuromuscular retraining and progressive loading exercises show promise in optimizing outcomes and reducing recurrence rates.

Conclusion: Osgood-Schlatter Disease is a complex, multifactorial condition requiring a personalized approach to management. Identifying and addressing risk factors such as lower limb biomechanics, muscle imbalances, and activity-related stressors are critical in both prevention and treatment. While conservative strategies remain the most effective approach, structured rehabilitation programs emphasizing tendon resilience and flexibility provide the best long-term outcomes. Future research should focus on refining rehabilitation techniques, optimizing early intervention strategies, and exploring the role of neuromuscular adaptations in disease progression. By integrating targeted interventions with evidence-based rehabilitation, healthcare providers can improve functional recovery and minimize the long-term impact of OSD on adolescent athletes.

Keywords: osgood-schlatter disease, knee pain, rehabilitation strategies, knee injuries, quadriceps and hamstring imbalance

INTRODUCTION

Osgood-Schlatter Disease (OSD) is a common cause of anterior knee pain in adolescents, primarily affecting those engaged in high-impact sports that involve repetitive quadriceps contractions [1,3]. The condition is characterized by inflammation and microtrauma at the tibial tuberosity, where the patellar tendon attaches to the developing apophysis. This excessive traction leads to pain, swelling, and, in some cases, fragmentation or ossicle formation at the site of insertion. OSD is considered a traction apophysitis, a disorder that arises due to the biomechanical stresses imposed on growing skeletal structures, particularly during periods of rapid growth [1-3]. Although often self-limiting, OSD can cause prolonged discomfort, restrict physical activity, and, in chronic cases, result in long-term functional impairment[7].

The pathophysiology of OSD is multifactorial, with mechanical overload, musculoskeletal imbalances, and individual anatomical predispositions contributing to its onset [13-16]. The repetitive tensile forces exerted by the quadriceps muscle, especially in activities involving jumping, sprinting, or kneeling, create excessive stress at the tibial tuberosity [18-21]. This results in inflammation, microavulsions, and in some cases, calcification or ossification at the tendon insertion site. Muscular factors, including quadriceps and hamstring tightness, have been implicated in increasing tibial tuberosity stress [14-16]. Additionally, limited ankle dorsiflexion and altered lower limb biomechanics, such as external tibial torsion and increased posterior tibial slope, have been identified as potential risk factors [18-20].

The epidemiology of OSD reveals a higher prevalence among male athletes, with peak incidence occurring between 12 and 15 years in boys and 8 to 13 years in girls, aligning with periods of accelerated growth [9]. Sports such as soccer, basketball, and gymnastics, which require frequent knee flexion and extension under load, are associated with an increased risk of OSD. However, recent studies suggest that the gender gap is narrowing, particularly with increased female participation in competitive sports [1-3]. The prevalence of bilateral involvement has been reported in up to 30% of cases, though symptoms often present asymmetrically [1-9].

Diagnosis of OSD is primarily clinical, based on a history of anterior knee pain exacerbated by physical activity and localized tenderness over the tibial tuberosity [2]. Common diagnostic maneuvers include pain elicitation upon resisted knee extension or direct palpation of the tibial tubercle. While radiographic imaging is not routinely required, it may be useful in cases of diagnostic uncertainty or severe symptoms [10,11]. X-rays may reveal fragmentation of the tibial tubercle, whereas ultrasound can provide detailed visualization of soft tissue

involvement, including patellar tendon thickening and apophyseal changes [1,2,3]. MRI is reserved for atypical cases or when ruling out alternative pathologies, such as patellar tendinopathy or osteochondritis dissecans [1,2,10].

The management of OSD remains predominantly conservative, focusing on symptom relief and functional rehabilitation [2,4]. Activity modification, including a temporary reduction in high-impact sports, is often recommended to prevent exacerbation of symptoms [8]. Structured physical therapy programs emphasizing quadriceps and hamstring flexibility, eccentric strengthening, and neuromuscular control have demonstrated effectiveness in promoting recovery. Nonsteroidal anti-inflammatory drugs (NSAIDs) are used to manage pain, though their role remains adjunctive rather than curative. In cases of persistent symptoms despite conservative management, additional interventions, such as patellar tendon offloading braces or corticosteroid injections, have been explored, though with limited evidence supporting their routine use. Surgical intervention is rare and typically reserved for chronic, refractory cases with persistent ossicle formation and mechanical irritation [14-19].

Despite being considered a self-limiting condition, OSD can significantly impact adolescent athletes, leading to prolonged discomfort and reduced sports participation [7,8]. Understanding its risk factors, pathophysiology, and optimal treatment strategies is crucial for improving patient outcomes and minimizing long-term sequelae [3]. This review aims to provide a comprehensive analysis of the risk factors contributing to OSD and evaluate the effectiveness of various management strategies, highlighting recent advancements in diagnosis, rehabilitation, and treatment approaches [1-3].

MATERIALS AND METHODS

This study is based on a comprehensive review of peer-reviewed literature examining the risk factors, pathophysiology, diagnosis, and management strategies for Osgood-Schlatter Disease (OSD). A systematic search was conducted using electronic databases, including PubMed, Scopus, and Google Scholar, to identify relevant studies published between 2000 and 2023. Search terms included “Osgood-Schlatter Disease,” “adolescent knee pain,” “patellar tendon stress,” “traction apophysitis,” “sports-related knee injuries,” and “rehabilitation strategies.” Studies were selected based on their relevance to OSD etiology, biomechanical risk factors, imaging techniques, and treatment modalities.

The inclusion criteria comprised randomized controlled trials, cohort studies, case-control studies, systematic reviews, and meta-analyses focusing on adolescent populations [2-8, 17-21]. Articles discussing conservative and surgical interventions, rehabilitation protocols, and long-term outcomes were prioritized. Studies exclusively examining adult populations, non-English publications, and those lacking clear methodologies were excluded. Data were categorized into key themes: risk factors and pathophysiology, diagnostic accuracy of clinical and imaging modalities, and effectiveness of various treatment approaches. The findings were synthesized to provide an evidence-based overview of OSD, emphasizing recent advancements in diagnosis, rehabilitation, and clinical management.

RESULTS

Osgood-Schlatter Disease (OSD) is a growth-related musculoskeletal condition that primarily affects adolescents undergoing rapid skeletal development. It is classified as a traction apophysitis of the tibial tuberosity caused by repetitive strain from the quadriceps muscle, which exerts excessive tensile forces through the patellar tendon [1-3]. This chronic mechanical overload leads to inflammation, microtrauma, and, in more severe cases, fragmentation or ossification at the tendon insertion site []10. The condition is most commonly observed in physically active individuals, particularly those engaged in sports that require frequent jumping, sprinting, and kneeling, which place significant stress on the extensor mechanism of the knee [8,21]. While often self-limiting, OSD can persist beyond skeletal maturity in some individuals, resulting in chronic pain, limited range of motion, and activity restrictions [7].

The pathophysiology of OSD is multifactorial, with a combination of mechanical, anatomical, and neuromuscular factors contributing to its onset [18-20]. During adolescence, rapid bone growth temporarily disrupts the balance between muscular strength and tendon elasticity, creating increased tension at the tibial tuberosity [13]. This process, when combined with high levels of physical activity, leads to repetitive microtrauma and inflammation at the site of patellar tendon attachment [16]. Muscular imbalances, particularly quadriceps tightness and hamstring inflexibility, have been strongly associated with increased tibial traction forces. Furthermore, studies suggest that external tibial torsion, increased posterior tibial slope, and limited ankle dorsiflexion contribute to abnormal loading patterns, further exacerbating stress on the apophysis [13]. Biomechanical factors, including overpronation of the foot and knee valgus alignment, may also influence the degree of patellar tendon tension, increasing susceptibility to tibial tuberosity irritation [3].

Epidemiologically, OSD is more prevalent in male athletes, with peak incidence occurring between 12–15 years in boys and 8–13 years in girls [9]. This gender difference is largely attributed to variations in skeletal development, as boys typically undergo longer periods of rapid growth, thereby prolonging the vulnerability of the tibial tuberosity [3]. However, with the increasing participation of female athletes in high-impact sports, the incidence of OSD in girls has risen, narrowing the previously observed gender disparity. Bilateral involvement occurs in up to 30% of cases, though symptoms are often asymmetrical. Athletes in sports such as soccer, basketball, volleyball, and gymnastics—where explosive quadriceps activation is frequent—exhibit a particularly high risk of developing OSD [8].

Clinically, OSD presents as anterior knee pain localized to the tibial tuberosity, which worsens with activity and improves with rest [21]. Patients frequently report tenderness over the tibial tuberosity, swelling, and, in some cases, an observable prominence of the affected area [2]. Functional limitations, such as discomfort during kneeling, squatting, or stair climbing, are common. Pain can range from mild to severe, with some individuals experiencing sharp, intermittent pain episodes, while others report persistent discomfort that interferes with daily activities [7]. In long-standing cases, chronic inflammation may lead to the formation of ossicles within the patellar tendon, further exacerbating symptoms [10].

Diagnosis of OSD is primarily clinical, based on history and physical examination findings. Direct palpation of the tibial tuberosity elicits pain, and resisted knee extension against resistance may further provoke symptoms [2]. Functional tests, such as pain during single-leg squats or step-down maneuvers, can help assess symptom severity. While imaging is not routinely required for diagnosis, it can be valuable in cases with atypical presentations or when ruling out alternative pathologies [3]. Lateral knee radiographs may reveal fragmentation or irregular ossification of the tibial tuberosity, while ultrasound can provide detailed visualization of soft tissue changes, including thickening of the patellar tendon and edema at the tibial insertion. MRI, though rarely necessary, is used for differential diagnosis in cases where patellar tendinopathy, osteochondritis dissecans, or stress fractures are suspected [7].

The primary symptom of Osgood-Schlatter Disease (OSD) is pain of varying intensity, which typically worsens with direct pressure on the affected site, particularly in positions such as kneeling. This pain is often localized to the anterior tibial tuberosity, where the patellar tendon inserts, and is accompanied by inflammation and hypersensitivity. Symptoms are most pronounced during physical activity, especially in sports that involve repetitive jumping, sprinting, or kneeling, and may lead to movement alterations such as limping [21]. In the early stages, discomfort is usually mild and intermittent, becoming more persistent and severe as the condition progresses.

A distinguishing feature of OSD is the thickening of the patellar tendon insertion, which can be detected through palpation and is frequently associated with localized tenderness. Pain is particularly elicited during resisted knee extension or counter-resisted knee flexion, as these movements increase tensile forces on the patellar tendon [2]. The underlying pathophysiology involves increased vascularization at the tibial tuberosity, leading to microtrauma and chronic irritation. Over time, excessive blood flow to the area can contribute to neovascularization, which may further perpetuate the inflammatory response and prolong symptom duration [13-16].

The clinical course of OSD varies widely among individuals. Guldhammer et al. reported that the median duration of symptoms was approximately 90 months (interquartile range, 24–150 months), with nearly 43% of patients experiencing daily pain [7]. Longitudinal studies suggest that while many individuals recover as they reach skeletal maturity, some experience prolonged discomfort that persists into adulthood. Kaya et al. found that around 50% of patients fully recovered within two years of diagnosis, although residual weakness and reduced quadriceps strength were observed in some cases. Variability in reported outcomes may be attributed to several factors, including the type and intensity of sports participation, the age of onset, methodological differences between studies, and environmental or genetic influences on musculoskeletal development [19].

Although OSD is generally considered a self-limiting condition, certain cases may become chronic, leading to long-term complications [10]. Persistent symptoms and repeated microtrauma can result in pseudoarthrosis, patella alta, genu recurvatum, and fragmentation or migration of bone fragments, all of which may contribute to reduced knee flexion and mechanical instability [1, 10]. In rare instances, chronic inflammation can lead to secondary pathologies such as osteochondromatosis, further complicating treatment and rehabilitation efforts. Given the potential for extended symptom duration and functional impairment, early intervention with structured

rehabilitation programs and activity modification is crucial in managing the condition and preventing long-term consequences [2,4].

The treatment of OSD remains predominantly conservative, focusing on symptom management, activity modification, and structured rehabilitation [8]. Temporary reduction or modification of high-impact activities, particularly those involving frequent knee flexion and extension, is recommended to alleviate stress on the tibial tuberosity. However, complete immobilization is generally avoided to prevent muscle deconditioning. Rehabilitation programs emphasize quadriceps and hamstring flexibility exercises to reduce excessive strain on the patellar tendon, while eccentric strengthening exercises help improve tendon resilience [4,8]. Neuromuscular control training, including balance and proprioceptive exercises, is increasingly recognized as an important component of rehabilitation, as it addresses underlying biomechanical deficits that contribute to abnormal loading patterns [4].

Pharmacological management involves the use of nonsteroidal anti-inflammatory drugs (NSAIDs) for short-term pain relief, though their role remains adjunctive rather than curative [2]. Corticosteroid injections are generally discouraged due to the potential risk of tendon atrophy and delayed healing. In cases where persistent symptoms interfere with activity despite conservative treatment, alternative interventions, such as patellar tendon offloading braces or extracorporeal shockwave therapy (ESWT), have been explored [2,8]. Emerging evidence suggests that ESWT may facilitate tendon healing and reduce pain in chronic cases, though further research is needed to establish standardized protocols.

Surgical intervention for Osgood-Schlatter Disease (OSD) is rarely indicated and is typically reserved for individuals who experience persistent pain and functional limitations despite prolonged conservative treatment. The most common indications for surgery include chronic mechanical irritation at the tibial tuberosity, unresolved pain due to ossicle formation, or the development of bony prominence that interferes with physical activity and daily function. Patients who fail to respond to rehabilitation, activity modification, and pharmacological interventions may require surgical evaluation to address structural abnormalities contributing to ongoing symptoms [2,10].

Several surgical techniques have been employed in the management of refractory OSD, with ossicle excision being the most frequently performed procedure. In cases where persistent ossification leads to impingement or inflammation, removal of the ossicle can significantly reduce pain and improve mobility. Tibial tubercle drilling has also been utilized to promote healing in patients with chronic tendon-bone interface disruption. Additionally, arthroscopic or open debridement may be necessary in cases where excessive fibrotic tissue or cartilaginous overgrowth contributes to prolonged symptoms. Studies have reported favorable outcomes following surgical intervention, with significant improvements in pain reduction, functional recovery, and return to physical activity.

Postoperative rehabilitation is critical to ensuring optimal recovery and preventing recurrence. The initial focus is on pain management and edema control, followed by progressive weight-bearing activities to restore functional mobility. Gradual reintroduction of range of motion exercises helps maintain flexibility, while strengthening protocols target the quadriceps, hamstrings, and surrounding musculature to improve knee stability.

Neuromuscular retraining and proprioceptive exercises are often incorporated to enhance movement efficiency and reduce reinjury risk [4]. Despite the success of surgical intervention in select cases, it remains a last-resort option, as the majority of OSD cases resolve with conservative management. Therefore, surgery is generally recommended only for patients with persistent, functionally limiting symptoms that significantly impair daily activities or athletic performance [1,2].

Prognosis for OSD is generally favorable, with symptoms resolving in most cases by the time skeletal maturity is reached [7]. However, some individuals may experience long-term sequelae, including residual tibial tuberosity prominence, intermittent pain with strenuous activity, and, in rare cases, patellar tendinopathy. Longitudinal studies indicate that early intervention with structured rehabilitation programs reduces the risk of prolonged symptoms and functional limitations [4,7]. Given the strong association between mechanical overload and disease progression, preventive strategies, including preseason flexibility and strength training programs, may be beneficial in reducing OSD incidence among young athletes [2,4,8].

Overall, OSD remains a well-recognized but incompletely understood condition with a complex interplay of biomechanical, anatomical, and developmental factors [18-21]. Advances in imaging techniques and rehabilitation protocols continue to refine treatment strategies, improving outcomes for affected adolescents. Future research should focus on optimizing rehabilitation techniques, identifying predictive markers for persistent symptoms, and developing targeted interventions that minimize disruption to adolescent sports participation while promoting long-term musculoskeletal health [3-7].

CONCLUSIONS

Osgood-Schlatter Disease (OSD) manifests as anterior knee pain, tenderness, and swelling over the tibial tuberosity, often exacerbated by physical activity [1-3]. The condition primarily affects adolescents during rapid growth phases, with risk factors including repetitive mechanical stress, muscle imbalances, and altered lower limb biomechanics. While self-limiting in most cases, persistent symptoms can lead to long-term discomfort and functional impairment [7-10].

Diagnosis is primarily clinical, with imaging reserved for atypical or severe cases. Conservative management remains the standard approach, focusing on activity modification, quadriceps and hamstring flexibility, and eccentric strengthening [8]. NSAIDs offer symptomatic relief, while corticosteroid injections are discouraged due to potential tendon damage. Surgical intervention is rarely required and is reserved for refractory cases with ossicle formation.

Early intervention through structured rehabilitation optimizes outcomes and reduces recurrence [7-8]. Preventive measures, including strength training and neuromuscular conditioning, may help minimize the risk of OSD in adolescent athletes. Future research should refine rehabilitation protocols and explore targeted treatment strategies to enhance long-term recovery and prevent complications [2-4].

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