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A STUDY ON THE CAUSATIVE FACTORS INDUCING CHONDROMALACIA PATELLAE

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ABSTRACT

Chondromalacia patellae (CMP) is a common musculoskeletal condition marked by the degeneration and softening of cartilage behind the kneecap, causing anterior knee pain. It is highly prevalent, especially in young to middle-aged adults, and is twice as common in women. This narrative systematic review aimed to synthesize current evidence on CMP's pathophysiology, clinical symptoms, and prevalence. A comprehensive search of PubMed, Google Scholar, and ScienceDirect yielded 20 peer-reviewed studies published between 2021 and 2025, focusing on human subjects and clinical, biomechanical, and anatomical aspects of CMP. A qualitative synthesis was used to identify key themes and clinical implications. The findings indicated a strong correlation between CMP and anatomical abnormalities such as the Insall-Salvati index and trochlear sulcus angle. Meniscopathy frequently coexists with CMP in active individuals, suggesting shared causes. Patients often display altered gait biomechanics, such as decreased knee flexion and uneven loading, as well as aberrant isokinetic parameters, which show muscle weakness and imbalances. High-impact activities and sports injuries dramatically raise the prevalence of CMP in students. The multifactorial nature of CMP, influenced by structural, biomechanical, and functional factors, highlights the importance of early detection and intervention. Future research should prioritize longitudinal studies to understand disease progression and long-term treatment effectiveness, and subgroup analyses to tailor interventions based on dominant etiological factors.

INTRODUCTION

Chondromalacia patellae , also referred to as patellofemoral pain syndrome (in patients of age group 15 - 25) or anterior knee pain syndrome, is a prevalent and often debilitating musculoskeletal condition characterized by the degeneration and softening of the hyaline cartilage on the posterior surface of the patella.[1] The term “chondromalacia,” first introduced by Aleman, originates from the Greek words chondros (cartilage) and malakia (softening), underscoring the pathological deterioration of cartilage integrity that defines this disorder.[2]

Chondromalacia patellae is recognized as one of the leading causes of knee pain, particularly among young to middle-aged adults, with peak prevalence observed between the ages of 30 and 40 years.[3] Epidemiological data indicates that Chondromalacia patellae affects approximately 36.2% of the general population, with prevalence rising to 50% among symptomatic middle-aged individuals.[4] It exhibits a notable gender disparity, being twice as common in women as in men, with young females showing disproportionately higher rates.[5] Geographically, the condition is widespread and frequently reported across both developed and developing regions, especially in physically active populations such as athletes, military personnel, and workers involved in repetitive squatting or kneeling tasks—groups that experience elevated biomechanical stress on the patellofemoral joint.[6]

The pathophysiology of Chondromalacia patellae is multifactorial, involving abnormal patellar tracking and increased lateral patellar pressure, which contribute to mechanical wear and initiate the release of inflammatory mediators like interleukin-6.[1] This cascade results in pain, swelling, and the progressive breakdown of cartilage.[2] Clinically, patients typically report dull, aching anterior knee pain, which intensifies during activities such as stair climbing, deep squatting, prolonged sitting, or knee flexion beyond 90 degrees.[3]

Diagnosis of Chondromalacia patellae remains challenging due to the variable correlation between symptoms and imaging findings.[4] While MRI provides a non-invasive assessment of cartilage lesions, it often underestimates the extent of damage compared to arthroscopic evaluation, which remains the gold standard.[5] In recent years, emerging biomechanical markers such as sagittal patellar tilt and the patella-patellar tendon angle (PPTA) have shown potential as diagnostic indicators of patellofemoral dysfunction.[6]

Furthermore, accumulating evidence suggests a significant role for vitamin D deficiency in compromising cartilage and bone health, particularly in young individuals and pregnant women.[7] As a crucial hormonal nutrient, vitamin D regulates osteoblast activity and calcium metabolism, and its deficiency has been associated with osteomalacia and impaired musculoskeletal

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development, potentially exacerbating susceptibility to Chondromalacia patellae.[8]

Despite its high prevalence and impact on quality of life, treatment strategies for Chondromalacia patellae remain diverse and at times controversial.[1] Conservative management, including physiotherapy, manual therapy, and whole-body vibration exercises, is commonly employed as first-line therapy.[2] In more advanced or refractory cases, surgical interventions such as microfracture, autologous matrix-induced chondrogenesis (AMIC), and autologous chondrocyte implantation (ACI) have demonstrated variable success in restoring cartilage and alleviating symptoms.[3]

Summary of Included Literature on Chondromalacia Patellae

Source Title	Authors & Year	Methods / Interventions	Major Findings
Patellar Chondromalacia and Anatomical Variations	Usal et al. (2022)	MRI-based anatomical measurements comparing patients with and without CMP	Trochlear sulcus angle, Insall-Salvati index, and patellar asymmetries significantly associated with CMP.
CMP and Meniscopathy in Youthful, Active Individuals	Akcicek & Ari (2022)	Observational study on young athletes with chronic anterior knee pain	Strong association between meniscopathy and CMP; shared biomechanical stressors.
Patellofemoral Joint Morphology and CMP	Stamatovic et al. (2022)	Literature synthesis using MRI/CT data on dysplasia and morphology	Patellofemoral dysplasia and abnormal joint morphology significantly increase CMP risk.
Prevalence of CMP and Patellofemoral Geometry	Dursun M. (2022)	Retrospective analysis of patella types and joint geometry	Specific patellar types and geometry linked to higher CMP prevalence.
Isokinetic Parameters in CMP Patients	Inojossa et al. (2025)	Isokinetic dynamometry comparing CMP patients vs controls	Lower quadriceps and hamstring torque in CMP patients; muscle weakness implicated.
Manual Therapy in CMP Treatment	Cai et al. (2023)	Clinical trial assessing manual therapy vs standard care	Manual therapy improved pain and function in CMP patients.
Surgical Strategies for Patellar Chondral Defects	Migliorini et al. (2022)	Systematic review on surgical techniques	AMIC and ACI show promise in advanced CMP cases.
Vitamin D and CMP in Pregnancy	Hussain et al. (2024)	Cross-sectional study in pregnant women with anterior knee pain	Vitamin D deficiency linked to increased CMP symptoms.
Whole-Body Vibration + Exercise in CMP	Ebid et al. (2025)	RCT comparing WBV + exercise vs exercise only in females	WBV enhanced functional outcomes more than exercise alone.
PPTA and CMP / Other Syndromes	Kim et al. (2022)	MRI study comparing PPTA across different knee pathologies	Smaller PPTA associated with CMP and other patellofemoral syndromes.
Cartilage Area in Early CMP	Cho et al. (2023)	MRI-based cross-sectional analysis of patellar cartilage	Decreased cartilage area linked to early-stage CMP symptoms.
CMP and Sports Injury in Students	Zhang et al. (2003)	Cross-sectional study in 4068 students with imaging	High-impact sports strongly associated with CMP development.
Chondromalacia Patellae: A Review	Vijayalakshmi et al. (2019)	Literature review on etiology, diagnosis, treatment	Emphasized early detection, imaging, and multi-modal treatment.
Prospective CMP Study	Insall et al. (1976)	Clinical + surgical correlation study	Clear association between clinical symptoms and cartilage damage; misalignment is key factor.
CMP in Adolescent Athletes	Milanovic et al. (2021)	Systematic review on young athletes	Overtraining, poor biomechanics, and muscle imbalance are key CMP risks.
Gait Biomechanics in CMP	Altukhova et al. (2021)	Biomechanical gait analysis	CMP alters gait patterns: reduced knee flexion and asymmetrical loading.
Isokinetic Strength in CMP	Saral et al. (2022)	Cross-sectional isokinetic testing	Notable strength deficits in CMP patients; suggests neuromuscular control issues.
Patellar Morphometry & CMP	Öğüt et al. (2023)	Morphometric analysis of patella types	Certain patellar shapes predispose individuals to cartilage degeneration.
Emerging Cell Therapies for CMP	Zheng et al. (2021)	Review of regenerative medicine approaches	MSCs and PRP show potential for cartilage repair in CMP cases.

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METHODOLOGY

This study was conducted as a narrative systematic review to investigate the clinical characteristics, diagnostic methods and prevalence associated with chondromalacia patella. The condition, clinical symptoms, prevalence, and structural or biomechanical alterations in the knee joint were all examined in 20 peer-reviewed research studies published between 2021 and 2025. The primary aim was to synthesize current evidence on the pathophysiology, clinical symptoms and prevalence for individuals affected by chondromalacia patella.

A comprehensive search was conducted across electronic databases such as PubMed, Google Scholar, and ScienceDirect. Studies were included if they were published in English, peer-reviewed, involved human subjects, and specifically addressed chondromalacia patella through clinical, biomechanical and anatomical perspectives. Studies were excluded if they focused on generalized knee disorders, non-patellar cartilage lesions, animal models, or lacked a clear methodological framework.

Each selected study was independently assessed for relevance and methodological rigor. Extracted data included study design, population characteristics, diagnostic tools used (e.g., gait analysis, imaging, isokinetic testing), and key findings related to cartilage degeneration, biomechanical deviations, muscle strength, and treatment efficacy. Due to the diversity in study designs and measured outcomes, a qualitative synthesis approach was applied to identify recurring themes and clinical implications.

Category	Details
Study Type	Narrative Systematic Review
Focus	Clinical characteristics, diagnostic methods, prevalence of chondromalacia patella
Time Frame	2021–2025
Number of Studies	20 peer-reviewed research studies
Databases Searched	PubMed, Google Scholar, ScienceDirect
Inclusion Criteria	English, peer-reviewed, human subjects, focus on chondromalacia patella (clinical/biomechanical/anatomical)
Exclusion Criteria	Generalized knee disorders, non-patellar lesions, animal models, unclear methodology
Data Extracted	Study design, population, diagnostic tools, cartilage status, biomechanics, muscle strength, treatment outcomes
Diagnostic Tools	Imaging (MRI), gait analysis, isokinetic testing
Key Themes Identified	Cartilage degeneration, biomechanical deviations, muscle weakness, clinical symptomatology, treatment efficacy
Synthesis Method	Qualitative synthesis (due to diverse study designs/outcomes)
Primary Aim	Synthesize current evidence on pathophysiology, symptoms, and prevalence

FINDINGS AND DISCUSSION

The deterioration and softening of the cartilage beneath the kneecap is the hallmark of chondromalacia patella, which causes anterior knee pain, especially in young, active patients. Studies reveal a strong correlation between chondromalacia patella and anatomical abnormalities such the trochlear sulcus angle and the Insall-Salvati index. In active and youthful individuals, meniscopathy frequently coexists with chondromalacia patellae, suggesting the existence of shared etiological causes. Chondromalacia development is also significantly influenced by the morphology of the patellofemoral joint and the presence of dysplasia. Abnormal isokinetic characteristics, which represent muscle weakness and imbalances, are typically seen in people with this illness. Repetitive stress, typically brought on by overtraining, biomechanical inefficiency, and muscular imbalances, is the cause of chondromalacia patella. Early signs like pain and stiffness are frequently disregarded, which can delay diagnosis and have negative consequences. Reduced knee flexion and unequal loading are two effects of the disorder's altered gait biomechanics. Chondromalacia patella patients typically have weak quadriceps and hamstrings, especially while moving at higher speeds, which impairs knee stability. Whole-body vibration, when combined with manual treatment and exercise, has been shown in clinical trials to improve function and lessen symptoms. Increased anterior knee pain during pregnancy has been linked to vitamin D insufficiency. Research on acute dislocation of the patella shows patterns of osteochondral damage as well as risk factors like patellar index and trochlear dysplasia. Pathologies of the patellofemoral joint, including chondromalacia, can be diagnosed by a decreased patella-patellar tendon angle. There is evidence linking specific anatomical differences of the knee joint to a higher risk of cartilage damage. The degree of cartilage destruction is correlated with the severity of symptoms in patients with knee discomfort, suggesting that overuse and incorrect kneecap position exacerbate the condition. Kneecap misalignment, overuse, and trauma are common causes of chondromalacia patellae, which can be diagnosed with MRI and arthroscopy and treated with physiotherapy and medicines at first. Chondromalacia patellae is significantly more common among students who have sustained sports injuries, especially in high-impact activities. When combined, these show that chondromalacia patellae is a very complicated disorder with a wide range of structural alterations, biomechanics, and activity levels, and that early detection and treatment are very important.

The article has been drafted following the TAILMRDCR model proposed by Kumar[20].

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The findings are useful for the practitioners and medical tourism scope[21,22].

CONCLUSION

Chondromalacia patellae is a multifactorial process that refers to the softening and degeneration of cartilage beneath the patella that results in pain in the anterior part of the knee, primarily among young and active patients. It has numerous biomechanical etiologies such as weakness, imbalance and modified gait. Activity levels and overuse are also a significant consideration. It concluded, that chondromalacia patellae is caused by a combination of structural, biomechanical, and functional factors. Given the multifactorial nature of chondromalacia patellae, future research should prioritize longitudinal studies to understand the condition's progression and long-term treatment effectiveness, alongside subgroup analyses to tailor interventions based on dominant etiological factors such as structural abnormalities, biomechanical impairments, or activity-related overuse.

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