Olgu Sunumu / Case Report

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Restoring Functionality in Severe Hip Deformities: Advanced Surgical Technique for Legg–Calvé–Perthes Disease Sequelae

Legg–Calvé–Perthes Hastalığı Sekellerinde İleri Cerrahi Yaklaşım: Bir Olgu Raporu

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ABSTRACT

Introduction:*This case study examines a specialized surgical intervention for an 18-year-old female patient with severe hip pain and impingement issues. These complications arise from deformities associated with her unilateral Legg-Calvé-Perthes disease. This condition severely affects hip function. The residual deformities from Legg–Calvé–Perthes disease (LCPD) are acknowledged for exacerbating joint degeneration and increasing symptomatic distress, particularly in adolescents and young adults. Therefore, comprehending the complex relationship between these deformities and their clinical implications is crucial for formulating effective treatment approaches to alleviate physical discomfort and enhance quality of life and function. These deformities present biomechanical and biological challenges that require tailored surgical interventions to restore joint function and reduce pain.*

Methods:*This study presents the case of an 18-year-old female patient with severe intra- and extra-articular impingement due to unilateral LCPD. A comprehensive surgical approach was employed, including hip dislocation, mosaicplasty with autografts, femoral head-neck osteochondroplasty and labral repair. Postoperative progress was monitored through clinical evaluations, radiographs, and Harris Hip Scores.*

Results:*Post-surgery, the patient demonstrated significant improvements in pain levels, hip range of motion, and functionality, with a Harris Hip Score increase from 62 preoperatively to 76 at two years postoperatively. Radiographic assessments confirmed the restoration of joint congruence, femoral head sphericity, and healing of osteochondral lesions.*

Conclusions:*This case highlights the efficacy of tailored hip preservation surgeries in managing complex residual deformities of LCPD. The report explores the details of the surgical methods used, the reasoning for the selected techniques, and the postoperative results, offering essential perspectives on managing comparable cases in the future. The surgical approach improves medium-term functionality and provides a foundation for preserving long-term joint health, reducing the risk of early degenerative arthritis. Future strategies addressing residual acetabular dysplasia could further enhance outcomes.*

Keywords: *Legg–Calvé–Perthes disease, Hip deformities, Mosaicplasty, Surgical dislocation, Femoral head-neck osteochondroplasty*

ÖZET

Giriş: *Bu olgu sunumu, 18 yaşında, sol kalçasında yoğun harreket ile ağrı ve ciddi intra ve ekstra-artiküler sıkışma semptomları yaşayan bir kadın hastanın kişiselleştirilmiş cerrahi tedavisini ele almaktadır. Legg–Calvé–Perthes hastalığı (LCPD) kaynaklı rezidüel kalça deformiteleri, özellikle genç yetişkinlerde eklem fonksiyonunu ciddi şekilde bozarak ağrıya ve erken dejeneratif değişikliklere yol açmaktadır. Bu biyomekanik ve biyolojik zorlukların üstesinden gelmek için kişiye özel planlanmış cerrahi müdahaleler gereklidir.*

Yöntemler: *Cerrahi müdahalede güvenli kalça dislokasyonu, ipsilateral femur başının ağırlık taşımayan bölgesinden alınan otolog greftlerle yapılan mozaikplasti, cam tipi sıkışmayı düzeltmek için femur baş-boyun osteokondroplastisi ve labrum onarımı gerçekleştirilmiştir. Postoperatif dönemde, klinik değerlendirmeler, radyografik görüntüleme ve Harris Hip Skoru ile hastanın iyileşme süreci takip edilmiştir.*

Sonuçlar: *Cerrahi sonrası hastanın ağrı seviyelerinde belirgin bir azalma ve kalça hareket açıklığında önemli iyileşmeler gözlenmiştir. Harris Hip Skoru, ameliyat öncesinde 62'den iki yıl sonrası takipte 76'ya yükselmiştir. Radyografik incelemeler, eklem uyumunun düzeldiğini, femur başı küreselliğinin sağlandığını ve osteokondral lezyonların kısmen iyileştiğini göstermiştir. Bununla birlikte, hafif derecedeki asetabular displazi, hastanın fonksiyonel sonuçlarını önemli ölçüde etkilememiştir.*

Tartışma: *Bu olgu, LCPD'ye bağlı karmaşık kalça deformitelerinin yönetiminde kişiselleştirilmiş cerrahi yaklaşımların önemini vurgulamaktadır. Bu tür müdahaleler, orta vadeli fonksiyonel iyileşmeyi artırırken, erken dejeneratif artriti önleyerek, uzun vadeli eklem sağlığını desteklemektedir. Gelecekteki araştırmalar, bu hastalarda özellikle rezidüel asetabular displaziyi ve osteokondral greft entegrasyonunu iyileştirmek için cerrahi tekniklerin daha da geliştirilmesine odaklanmalıdır. Bu rapor, benzer vakaların yönetimi için değerli bir rehber sunmaktadır.*

Anahtar Kelimeler: *Legg–Calvé–Perthes hastalığı, Kalça deformiteleri, Mozaikplasti, Cerrahi dislokasyon, Femur baş-boyun osteokondroplastisi*

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INTRODUCTION

Legg–Calvé–Perthes disease (LCPD) is a pediatric orthopedic disorder marked by idiopathic osteonecrosis of the proximal femoral epiphysis[1]. The disease progresses through several stages, including necrosis, fragmentation, reossification, and ultimately a sequelae phase, which can result in permanent deformities[2]. After the active phase of the disease resolves, the severity of symptoms and the degree of hip dysfunction largely depend on the residual deformity, the shape of the femoral head, and joint congruence[3,4]. These factors play a critical role in determining the long-term prognosis.

Residual deformities in the femoral head may manifest as coxa magna with lateral extrusion, coxa plana, or chondral damage caused by epiphyseal necrosis. Additionally, complications such as coxa breva and trochanteric overgrowth may arise due to disruption of the proximal growth plate. These deformities can lead to secondary changes in the acetabulum, including retroversion, insufficient femoral head coverage, and progressive degeneration of the articular cartilage and labrum, which negatively impact the long-term outcomes[3,5,6].

Effective treatment necessitates a comprehensive understanding of the condition's varied pathological presentations, achieved through detailed history-taking, physical examination, and advanced imaging. To restore proper hip anatomy and biomechanics, a tailored surgical approach addressing both intra- and extra-articular abnormalities, as well as femoral and acetabular deformities, is essential[7,8]. The ultimate goal is to achieve a stable, well-aligned joint with improved range of motion. In cases with significant joint dysfunction, the focus shifts toward enhancing the patient's quality of life and postponing the need for joint replacement.

CASE

A young female patient, who is currently 18 years of age, presented to the clinic with complaints of persistent pain located in her left hip, alongside a medical history that includes a diagnosis of left Legg–Calvé–Perthes disease (LCPD) that she had been dealing with since childhood. This particular disease had first manifested itself when she was just 8 years old, specifically affecting her left hip, and had been treated through conservative management strategies at a different healthcare facility prior to this visit. Upon reviewing her overall health status, it was noted that the patient did not report any other significant medical conditions or health issues that would complicate her current situation.

During the clinical examination, a thorough assessment revealed symptoms that were consistent with considerable intra- and extra-articular impingement, which significantly interfered with her daily living activities and her ability to participate in various sports and physical exercises. Upon assessment of the passive range of motion in her left hip, it was apparent that significant limitations existed, as evidenced by flexion restricted to 80°, complete restriction of extension at 0°, abduction limited to only 25°, adduction at 10°, internal rotation at 15°, and external rotation also at 15°. Despite these significant limitations in her range of motion, it was encouraging to observe that her hip abductor function remained intact, and there were no notable abnormalities identified in the rotational profile of her lower extremities during the examination. The Harris hip score, which is a widely used assessment tool for hip function, was recorded at a value of 62 points indicating a moderate level of impairment.

Preoperative radiographs (Fig 1.2.) and CT scans showed significant residual deformity of left proximal femur, including coxa magna, coxa plana, and coxa breva, with proximal migration of the greater trochanter. Additionally, there was a large central osteochondral defect, shallow acetabula with lateral

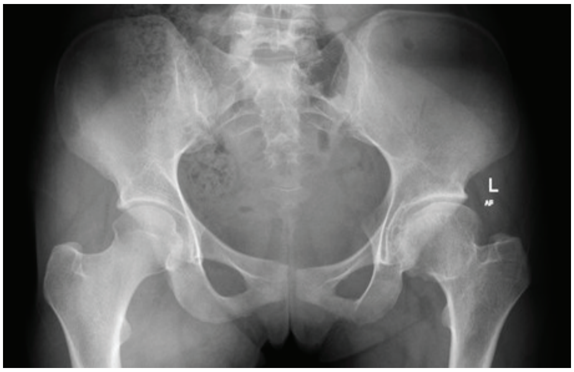

FIG 1. Preoperative pelvis anteroposterior (AP) X-ray showing significant femoral head deformity.

undercoverage, and femoral head extrusion; classified as Stulberg's grade 3 deformity[3].

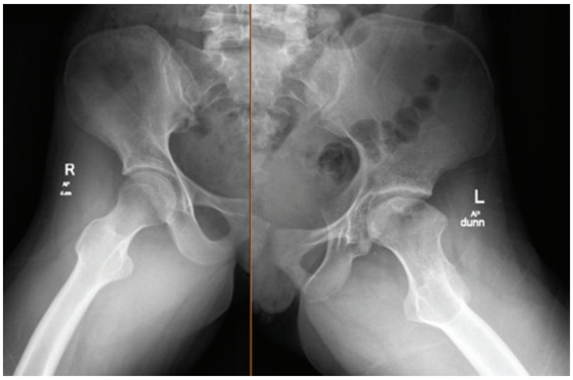

FIG 2. Preoperative bilateral Dunn X-ray demonstrating aspherical deformation of the left femoral head with a reduced head-neck offset, consistent with cam-type femoroacetabular impingement

Following an exhaustive deliberation concerning the available therapeutic alternatives with the patient and her relatives, it was resolved to undertake hip preservation surgery, prioritizing the correction of the femoral deformity initially. This decision was based on the patient's significant intra- and extra-articular impingement symptoms, limited range of motion, and radiographic findings consistent with Stulberg grade 3 deformity, including coxa magna, coxa plana, and proximal migration of the greater trochanter. Given the presence of a large central osteochondral defect, hip preservation techniques were favored over total hip arthroplasty to maintain native joint integrity and delay the need for future joint replacement[9].

Femoral head-neck osteochondroplasty was chosen to restore sphericity and improve head-neck offset, thereby reducing impingement and mechanical dysfunction. This approach has been supported by previous studies showing that osteochondroplasty improves joint congruency and delays the progression of osteoarthritis in LCPD sequelae[10]. Additionally, mosaicplasty was performed to address the osteochondral defect, as studies have demonstrated that osteochondral autograft transplantation leads to favorable cartilage integration and improved load distribution in femoral head lesions[11].

The decision to delay acetabular interventions was based on the adaptive remodeling potential of the acetabulum and the possibility that residual symptoms might resolve following femoral correction alone. This is consistent with findings from Söylemez et al. (2022), who reported that conservative and staged approaches in select patients can optimize functional outcomes while preserving hip biomechanics[12]. However, if persistent dysplasia or joint instability remained, secondary periacetabular osteotomy or acetabular rim trimming would be considered in a staged manner.

1. Anesthesia and Patient Positioning

●The patient was placed under general anesthesia in a lateral decubitus position. This positioning provided optimal access to the hip joint and facilitated a safe surgical dislocation.[13]

2. Approach and Surgical Dislocation

•Surgical Approach: A direct lateral approach and trochanteric osteotomy was used to access the proximal femur and acetabulum effectively. A partial-thickness osteotomy of the greater trochanter was performed, carefully preserving the abductor muscle attachments to maintain their functionality.

•Z-Shaped Capsulotomy: A Z-shaped capsulotomy was performed to allow safe dislocation of the hip joint without compromising vascular supply.

•Examination of the Femoral Head: Upon dislocation, the femoral head was examined, revealing an ovoid shape with a central osteochondral defect.

3. Management of Osteochondral Defect

●Assessment of Defect: After surgical dislocation, a central osteochondral defect in the femoral head was identified. This defect was characterized by significant cartilage loss, exposing the underlying subchondral bone, which could compromise joint congruence and lead to progressive degeneration if left untreated. (Fig 2.1)

●Debridement: The defect was meticulously debrided to remove loose or damaged cartilage and expose stable surrounding cartilage and vascularized subchondral bone. This step is critical to ensure a healthy interface for the subsequent grafting process.

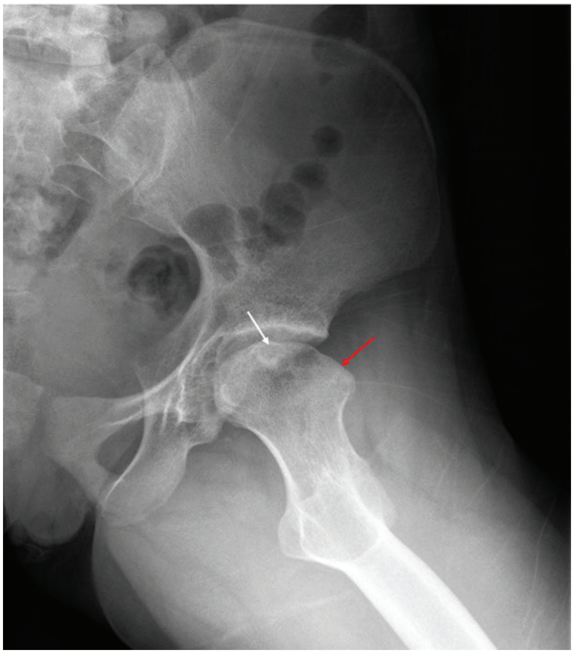

FIG 2.1 The white arrow indicates the osteochondral defect, while the red arrow marks the donor site in the non-weight-bearing peripheral region of the femoral head.

●Mosaicplasty Technique:

○ Channel Drilling: Three cylindrical channels were created perpendicular to the defect using specialized tubular chisels. These channels ensured optimal fit and alignment for the grafts.

○ Graft Harvesting: Osteochondral plugs were harvested from the non-weight-bearing peripheral region of the ipsilateral femoral head. This approach minimizes donor-site morbidity while providing grafts with high biological compatibility.

○ Graft Placement: The harvested plugs were precisely placed into the prepared channels, ensuring they were flush with the surrounding cartilage. İmpinging against acetabulum which will be excised later. Proper alignment and integration of the grafts are crucial for restoring the structural and functional integrity of the femoral head.(Fig 2.2)

4. Femoral Head-Neck Osteochondroplasty

● Indications: Preoperative imaging and intraoperative examination revealed cam-type femoroacetabular impingement, characterized by an aspherical femoral head and an irregular head-neck junction. These deformities created shear forces at the acetabular cartilage, leading to mechanical dysfunction and pain.

● Reshaping the Femoral Head:

○ Excess Bone Removal: A large cheilectomy was performed to remove excess bone from

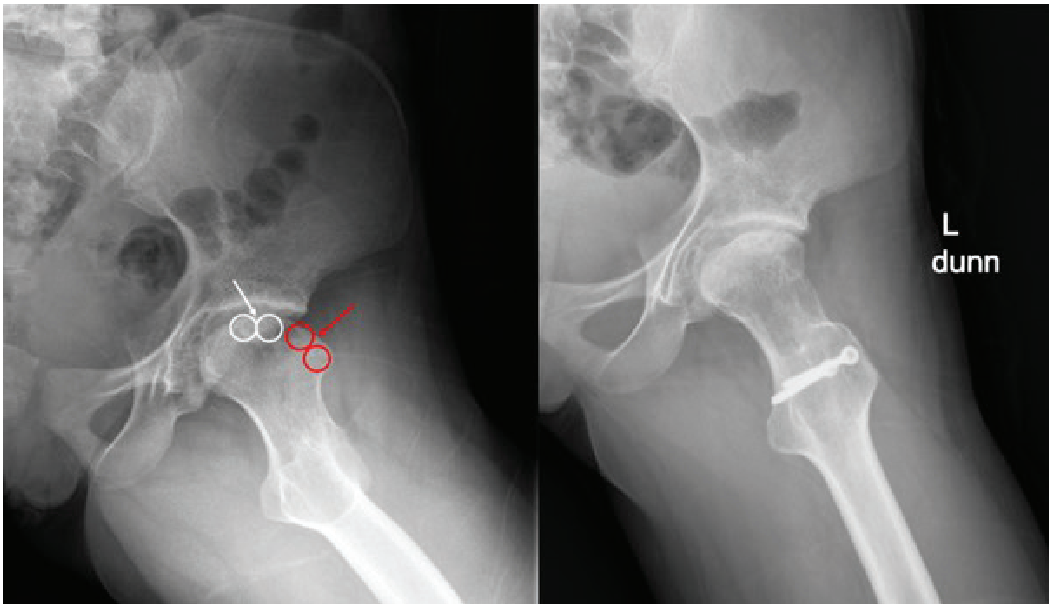

FIG 2.2 The white circle highlights the osteochondral defect, while the red circle indicates the donor site in the non-weight-bearing peripheral region of the femoral head. On the right, the postoperative X-ray is shown

the anteroinferior, posteroinferior, and lateral regions of the femoral head. This step aimed to restore a more spherical shape to the femoral head, improving its fit within the acetabulum.

○ Head-Neck Junction Smoothing: The head-neck junction was smoothed to increase the head-neck offset. This anatomical correction alleviates impingement and enhances the joint's range of motion.

● Dynamic Assessment: Intraoperative assessments were conducted to ensure proper restoration of joint congruence. The orthopedic surgeon assessed the hip joint by conducting a series of maneuvers, such as flexion, internal rotation, and abduction, to verify the lack of any remaining impingement.

● Fixation: The advanced trochanter was secured with two 4.5 mm full-threaded cannulated screws. Proper fixation ensures stability during the healing process and facilitates early mobilization.

6. Closure

● Capsulorrhaphy: The hip capsule was repaired to ensure joint stability.

● Wound Closure: The surgical site was closed in layers, and a subfascial suction drain was placed to manage postoperative fluids. (Fig 3.4.).

7. Postoperative Management

● The patient was allowed partial weight-bearing with assistive devices for six weeks, with restrictions on hip flexion beyond 90° and active abduction. Full weight-bearing and progressive range-of-motion exercises were initiated after six weeks, leading to gradual functional recovery.

During follow-up, the patient reported significant pain relief and functional improvement, particularly in hip flexion, with modest gains in internal and external rotation. The images demonstrate improved femoral head sphericity and partial resolution of the central osteochondral lesion, despite residual acetabular dysplasia. A structured postoperative rehabilitation protocol was followed, beginning with non-weight-bearing for the first month, followed by progressive weight-bearing and range-of-motion exercises to enhance joint mobility and prevent stiffness[12]. Additionally, targeted strengthening of the hip abductors and core muscles, along with proprioceptive training, was incorporated to improve dynamic stability and functional recovery[11]. Two years after the surgery, the patient remains actively engaged in daily activities with only minor complaints and minimal functional limitations. The Harris Hip Score has improved to 76, and the Visual Analog Scale (VAS) pain score has decreased from 7 preoperatively to 2 at the latest follow-up, indicating significant pain reduction. Follow-up radiographs (Fig. 5.6) indicate near-complete radiological healing of the osteochondral lesion in the left hip. The femoral head appears more congruent and spherical, with preserved joint space. However, the central osteochondral lesion in the left hip persists, though its size and depth have significantly decreased, indicating partial graft integration.

FIG 3. Postoperative pelvis anteroposterior (AP) X-ray demonstrating improved femoral head sphericity following osteochondroplasty and mosaicplasty

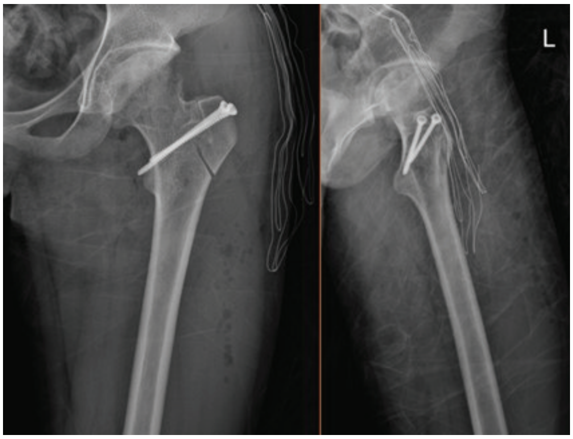

FIG 4. Postoperative femur anteroposterior (AP) and Dunn X-ray images showing improved femoral head sphericity and restoration of the head-neck contour following osteochondroplasty and mosaicplasty.

FIG 5. Two-year postoperative pelvis anteroposterior (AP) X-ray showing improved femoral head congruency and near-complete healing of the osteochondral lesion. Joint space is preserved, and the femoral head maintains a more spherical shape, although mild residual dysplasia persists.

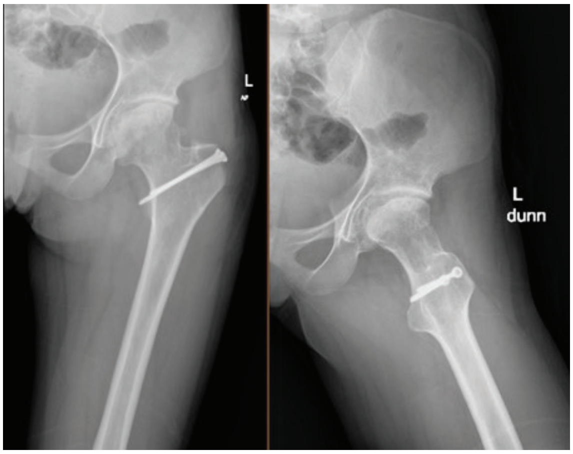

FIG 6. Two-year postoperative femur anteroposterior (AP) and Dunn X-ray images.

DISCUSSION

The orthopedic intervention for the residual deformities associated with Legg–Calvé–Perthes Disease (LCPD) continues to pose significant challenges. Deformities of the hip resulting from biomechanical changes and joint incongruences, further exacerbated by osteochondral injuries, markedly elevate the likelihood of developing symptomatic coxofemoral arthritis at early age[3]. The disease has a variable prognosis, influenced by patient age, the severity of femoral head involvement, and the degree of residual deformity at skeletal maturity[5,6]. Treatment strategies aim to preserve the femoral head's sphericity, maintain hip function, and delay the need for joint replacement. In cases with significant femoral head deformity and mechanical dysfunction, surgical intervention becomes necessary to restore joint congruence and improve biomechanics[9].

A multitude of surgical techniques has emerged to effectively address the complex sequelae associated with LCPD. Among these, total hip arthroplasty (THA) is an option but is generally reserved for advanced cases with severe osteoarthritis, as its long-term outcomes in young patients are less favorable due to high revision rates and implant wear[14]. Instead, hip preservation techniques, such as femoral osteotomy, osteochondroplasty, and cartilage restoration procedures, have been increasingly preferred to maintain native joint integrity and prolong hip function[10, 15-18]. Recent global analyses indicate that the choice of surgical technique varies significantly by geographic region, with North America favoring pelvic osteotomies, while Europe and Asia more frequently utilize femoral osteotomies[19]. This suggests that surgeon preference and regional treatment philosophies play a role in determining outcomes, further highlighting the need for individualized patient-specific approaches.

One of the primary surgical strategies in LCPD is femoral head-neck osteochondroplasty, which aims to reshape the femoral head and improve head-neck offset to mitigate femoroacetabular impingement (FAI)[7,13]. This technique is particularly effective in patients with cam-type deformities, as it reduces shear stress at the acetabular cartilage, lowering the risk of labral injury and early arthritis[18,20]. Studies suggest that osteochondroplasty significantly improves hip range of motion and reduces pain scores, with long-term follow-ups showing sustained functional benefits[11]. However, osteochondroplasty alone may be insufficient in cases with extensive femoral head asphericity or large osteochondral defects, necessitating additional cartilage restoration techniques[21].

Mosaicplasty, an autologous osteochondral transplantation technique, has demonstrated promising outcomes in restoring femoral head cartilage integrity[16,22]. This method allows for direct transplantation of hyaline cartilage from non-weight-bearing areas, promoting graft integration and improving load distribution within the joint[23]. In LCPD patients with osteochondral defects, mosaicplasty has been shown to reduce pain, restore load-bearing function, and delay joint degeneration[24]. A recent systematic review suggests that mosaicplasty results in superior functional outcomes compared to microfracture techniques, particularly in younger patients with well-contained lesions[10]. However, its success is influenced by factors such as graft size, depth of the lesion, and postoperative rehabilitation, necessitating meticulous surgical execution and structured rehabilitation protocols[24].

In cases of persistent coxa magna, femoral head asphericity, and severe residual deformity, head reduction osteotomy has been proposed as an effective intervention[17,20]. This technique aims to reduce femoral head volume while preserving vascularity, thereby restoring joint congruency and preventing impingement. Studies have indicated that head reduction osteotomy leads to significant functional improvement, with lower rates of osteoarthritis progression in long-term follow-up[3]. However, due to its technically demanding nature and the risk of disrupting femoral head blood supply, patient selection remains critical. Some authors have suggested combining head reduction osteotomy with periacetabular osteotomy to optimize acetabular coverage and minimize mechanical stress on the joint[4,25].

For patients with residual acetabular dysplasia and femoral head subluxation, periacetabular osteotomy (PAO) and intertrochanteric osteotomy (ITO) serve as important adjunct procedures[6,8]. PAO enhances femoral head containment and reduces joint contact pressures, thereby delaying the onset of secondary osteoarthritis[7]. However, studies indicate that PAO alone may not be sufficient in patients with severe femoral head deformity, necessitating combined procedures such as osteochondroplasty or femoral osteotomy[12]. In contrast, intertrochanteric osteotomy, which alters femoral neck orientation, has shown positive outcomes in patients with persistent femoral head malrotation and joint instability[15].

In this case, a combination of femoral head-neck osteochondroplasty and mosaicplasty was performed to address the patient's cam deformity and central osteochondral defect. The decision to avoid acetabular interventions at the initial stage was based on the potential for adaptive acetabular remodeling, a phenomenon observed in younger patients following femoral correction[6,8]. Postoperatively, the patient followed a structured rehabilitation protocol, including initial non-weight-bearing, progressive load-bearing exercises, and neuromuscular strengthening, which are essential for optimal cartilage integration and functional recovery[11].

At the two-year follow-up, the patient demonstrated substantial functional improvement, as evidenced by an increased Harris Hip Score (from 62 to 76) and a reduction in VAS pain score (from 7 to 2). Radiographic assessment revealed near-complete healing of the osteochondral lesion, though mild residual dysplasia persisted. Given these findings, long-term monitoring is warranted to assess the potential need for secondary periacetabular osteotomy or rim trimming if symptoms persist[12].

This study is limited by its single-case design, which restricts the generalizability of findings. Additionally, while the surgical outcomes were evaluated using functional scores and radiographic assessments, longer follow-up is required to determine the durability of the surgical intervention and the risk of future degenerative changes. Further comparative studies involving a larger cohort and long-term follow-up data would be valuable to better define the optimal surgical strategy for similar cases. Moreover, global variations in surgical techniques, as reported by Braito et al. (2021), highlight the need for further studies comparing different hip preservation approaches across diverse patient populations[19]. Finally, while hip arthroscopy has shown potential in managing post-LCPD sequelae, its role in combination with other preservation techniques warrants further investigation[26].

CONCLUSION

This study highlights a patient-specific and comprehensive approach to managing Legg–Calvé–Perthes disease (LCPD) sequelae, emphasizing the importance of preserving joint integrity and optimizing long-term function in young patients. Residual deformities following LCPD can accelerate cartilage degeneration, restrict range of motion, and lead to early-onset osteoarthritis, necessitating a proactive treatment strategy. Early surgical intervention, including safe surgical hip dislocation and femoral head reshaping, plays a critical role in restoring joint congruency and alleviating mechanical impingement. Advanced techniques such as osteochondroplasty and mosaicplasty allow for precise correction of deformities and cartilage restoration, reducing the risk of progressive joint deterioration. In cases with residual acetabular dysplasia, staged interventions such as periacetabular osteotomy may be required, aligning with global treatment trends that favor combined approaches for more severe deformities.

The findings of this study reinforce the need for an individualized surgical plan that balances immediate symptom relief with long-term hip preservation. While early biomechanical corrections can significantly improve functional outcomes, long-term follow-up is essential to assess the durability of these interventions and identify potential secondary procedures. Given the variation in surgical techniques across different regions and patient populations, future research should focus on comparing hip preservation strategies in larger cohorts to determine the most effective treatment pathways. By addressing both intra- and extra-articular deformities with a structured, evidence-based approach, hip preservation surgery offers a promising avenue for improving joint longevity and delaying degenerative changes in patients recovering from LCPD.

REFERENCES

1. Pavone V, Chisari E, Vescio A, Lizzio C, Sessa G, Testa G. Aetiology of Legg-Calvé-Perthes disease: A systematic review. World J Orthop. 2019 Mar 18;10(3):145-165. doi: 10.5312/wjo.v10.i3.145. PMID: 30918798; PMCID: PMC6429000.
2. Waldenström H. The Definite Form of the Coxa Plana. Acta Radiol. 2016 Jul;57(7):e79-94. doi: 10.1177/0284185116642923. PMID: 27298484.
3. Maleki A, Qoreishy SM, Bahrami MN. Surgical Treatments for Legg-Calvé-Perthes Disease: Comprehensive Review. Interact J Med Res. 2021 May 3;10(2):e27075. doi: 10.2196/27075. PMID: 33938444; PMCID: PMC8129878.
4. Pinheiro M, Dobson CA, Perry D, Fagan MJ. New insights into the biomechanics of Legg-Calvé-Perthes' disease: The Role of Epiphyseal Skeletal Immaturity in Vascular Obstruction. Bone Joint Res. 2018 Feb;7(2):148-156. doi: 10.1302/2046-3758.72.BJR-2017-0191.R1. PMID: 29437587; PMCID: PMC5895949.
5. Eid MA. Hip preservation surgery for adolescents and young adults with Post-Perthes Sequelae. Acta Orthop Belg. 2016 Dec;82(4):821-828. PMID: 29182124.
6. Maranho DA, Ferrer M, Kalish LA, Hovater W, Novais EN. The acetabulum in healed Legg-Calvé-Perthes disease is cranially retroverted and associated with global reduction of femoral head coverage: a matched-cohort study. J Hip Preserv Surg. 2020 Feb 7;7(1):49-56. doi: 10.1093/jhps/hnaa003. PMID: 32382429; PMCID: PMC7195929.
7. Viamont-Guerra MR, Bonin N, May O, Le Viguelloux A, Saffarini M, Laude F. Promising outcomes of hip mosaicplasty by minimally invasive anterior approach using osteochondral autografts from the ipsilateral femoral head. Knee Surg Sports Traumatol Arthrosc. 2020 Mar;28(3):767-776. doi: 10.1007/s00167-019-05442-1. Epub 2019 Feb 28. PMID: 30820604.
8. Wei YP, Lai YC, Chang WN. Anatomic three-dimensional model-assisted surgical planning for treatment of pediatric hip dislocation due to osteomyelitis. J Int Med Res. 2020 Feb;48(2):300060519854288. doi: 10.1177/0300060519854288. Epub 2019 Jul 1. PMID: 31256732; PMCID: PMC7610018.
9. Santos Santana MA Sr, Bahiense Guimarães L Sr, Correia Mendes L Sr, Leal Varjao L Sr. Effectiveness of therapeutic methods for Legg-Calvé-Perthes disease according to staging, limits of conservative treatment: a systematic review with meta-analysis. Orthop Rev (Pavia). 2024 Aug 15;16:122123. doi: 10.52965/001c.122123. PMID: 39156912; PMCID: PMC11329377.
10. Caldaci A, Testa G, Dell'Agli E, Sapienza M, Vescio A, Lucenti L, Pavone V. Mid-Long-Term Outcomes of Surgical Treatment of Legg-Calvè-Perthes Disease: A Systematic Review. Children (Basel). 2022 Jul 27;9(8):1121. doi: 10.3390/children9081121. PMID: 36010012; PMCID: PMC9406809.
11. Zhamilov, V., Basa, C. D., Kaçmaz, İ. E., Reisoğlu, A., & Agus, H. (2021). Functional Outcomes of Soft Tissue Release Surgery in Advanced Legg-Calve-Perthes Disease. Turk J Hip Surg, 1(3), 84-89. https://doi.org/10.5505/TJHS.2021.66375.
12. Söylemez MS, Eceviz E, Esenkaya İ, Eren A. Radiographical and clinical results of a new conservative treatment algorithm in Legg-Calvè-Perthes disease: A retrospective study. Acta Orthop Traumatol Turc. 2022 May;56(3):187-193. doi: 10.5152/j.aott.2022.21293. PMID: 35703506; PMCID: PMC9612645.
13. Ganz R, Gill TJ, Gautier E, Ganz K, Krügel N, Berlemann U. Surgical dislocation of the adult hip a technique with full access to the femoral head and acetabulum without the risk of avascular necrosis. J Bone Joint Surg Br. 2001 Nov;83(8):1119-24. doi: 10.1302/0301-620x.83b8.11964. PMID: 11764423.
14. Tabutin J, Cambas PM. Hip arthroplasty up to the age of 30 and considerations in relation to subsequent revision. Hip Int. 2009 Jul-Sep;19(3):201-5. doi: 10.1177/112070000901900302. PMID: 19891048.
15. Rebello G, Spencer S, Millis MB, Kim YJ. Surgical dislocation in the management of pediatric and adolescent hip deformity. Clin Orthop Relat Res. 2009 Mar;467(3):724-31. doi: 10.1007/s11999-008-0591-y. Epub 2008 Nov 12. PMID: 19002743; PMCID: PMC2635463.
16. Anderson LA, Erickson JA, Severson EP, Peters CL. Sequelae of Perthes disease: treatment with surgical hip dislocation and relative femoral neck lengthening. J Pediatr Orthop. 2010 Dec;30(8):758-66. doi: 10.1097/BPO.0b013e3181fcbaaf. PMID: 21102198; PMCID: PMC3031125.
17. Paley D. The treatment of femoral head deformity and coxa magna by the Ganz femoral head reduction osteotomy. Orthop Clin North Am 2011; 42: 389.
18. Albers CE, Steppacher SD, Ganz R, Siebenrock KA, Tannast M. Joint-preserving surgery improves pain, range of motion, and abductor strength after Legg-Calvé-Perthes disease. Clin Orthop Relat Res. 2012 Sep;470(9):2450-61. doi: 10.1007/s11999-012-2345-0. PMID: 22528379; PMCID:

PMC3830093.

19. Braito M, Wolf S, Dammerer D, Giesinger J, Wansch J, Biedermann R. Global differences in the treatment of Legg-Calvé-Perthes disease: a comprehensive review. Arch Orthop Trauma Surg. 2021 Jan;141(1):1-16. doi: 10.1007/s00402-020-03392-9. Epub 2020 Mar 14. PMID: 32172318.
20. Siebenrock KA, Anwander H, Zurmühle CA, Tannast M, Slongo T, Steppacher SD. Head reduction osteotomy with additional containment surgery improves sphericity and containment and reduces pain in Legg-Calvé-Perthes disease. Clin Orthop Relat Res. 2015 Apr;473(4):1274-83. doi: 10.1007/s11999-014-4048-1. PMID: 25384430; PMCID: PMC4353505.
21. Novais EN. Application of the surgical dislocation approach to residual hip deformity secondary to Legg-Calvé-Perthes disease. J Pediatr Orthop. 2013 Jul-Aug;33 Suppl 1:S62-9. doi: 10.1097/BPO.0b013e318281132d. PMID: 23764795.
22. Girard J, Roumazeille T, Sakr M, Migaud H. Osteochondral mosaicplasty of the femoral head. Hip Int. 2011 Sep-Oct;21(5):542-8. doi: 10.5301/HIP.2011.8659. PMID: 21948031.
23. Hangody L, Füles P. Autologous osteochondral mosaicplasty for the treatment of full-thickness defects of weight-bearing joints: ten years of experimental and clinical experience. J Bone Joint Surg Am. 2003;85-A Suppl 2:25-32. doi: 10.2106/00004623-200300002-00004. PMID: 12721342.
24. Athanasiou V, Argyropoulou E, Antzoulas P, Lakoumentas J, Diamantakis G, Gliatis J. Mosaicplasty of the Femoral Head: A Systematic Review and Meta-Analysis of the Current Literature. Cureus. 2022 Nov 24;14(11):e31874. doi: 10.7759/cureus.31874. PMID: 36579298; PMCID: PMC9792298.
25. Clohisy JC, Pascual-Garrido C, Duncan S, Pashos G, Schoenecker PL. Concurrent femoral head reduction and periacetabular osteotomies for the treatment of severe femoral head deformities. Bone Joint J. 2018 Dec;100-B(12):1551-1558. doi: 10.1302/0301-620X.100B12.BJJ-2018-0030.R3. PMID: 30499318.
26. Goyal T, Barik S, Gupta T. Hip Arthroscopy for Sequelae of Legg-Calve-Perthes Disease: A Systematic Review. Hip Pelvis. 2021 Mar;33(1):3-10. doi: 10.5371/hp.2021.33.1.3. Epub 2021 Mar 2. PMID: 33748020; PMCID: PMC7952270.