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Review Article

Orthopedic Joint Preservation: A Comprehensive Review

Bilal Mohamad Ali Obeid*

Department of Orthopaedic, Gardenia Medical Centre, Doha, Qatar

Abstract

This comprehensive review article delves into the intricate realm of orthopedic joint preservation with a focus on surgical techniques, innovative treatments, rehabilitation protocols, and long-term outcomes. Within the orthopedic landscape, joint preservation plays a crucial role in enhancing patient quality of life and functional outcomes. The article delivers a detailed exploration of various surgical techniques utilized for joint preservation, encompassing arthroscopy, cartilage repair, osteotomy, and ligament reconstruction. By scrutinizing the indications, outcomes, and potential complications associated with these procedures, the article aids in providing a comprehensive understanding for practitioners. Moreover, it delves into the realm of cutting-edge treatments such as regenerative medicine, stem cell therapy, and biologic agents, shedding light on their significant role in promoting joint preservation and fostering tissue healing. Rehabilitation protocols for joint preservation are also thoroughly evaluated, underlining the pivotal role of early mobilization, tailored physical therapy regimens, and patient education in fostering optimal outcomes while averting potential complications. Through an assessment of long-term outcomes post joint preservation interventions including functional improvements, pain management, and patient contentment, the article endeavors to gauge the efficacy and longevity of these interventions. By offering a nuanced overview of the current state of joint preservation in orthopedics, the article extends valuable insights to orthopedic surgeons, researchers, and healthcare professionals actively engaged in managing joint disorders.

Keywords

Articular Cartilage Lesions, Joint Preservation, Osteoarthritis, Orthobiologics, Innovative Treatments, Cartilage Restoration, Stem Cells, Ozone Therapy

1. Introduction

Orthopedic joint preservation is an imperative notion in contemporary orthopedics, encompassing a wide array of surgical methodologies and inventive therapies designed to safeguard joint functionality and avert the necessity for joint replacement. These methodologies consist of arthroscopy, osteotomy, and cartilage restoration. [1] Biological therapies are currently being investigated as possible interventions for the preservation of joints. These therapies have the objective of utilizing the inherent healing abilities of the body in order to reinstate and mend joint tissue that has undergone damage. Moreover, the field of regenerative medicine, which focuses on the progress of innovative treatments for the replacement or regeneration of afflicted or injured tissue, is currently under examination with regards to the preservation of joints. This emerging field aims to employ sophisticated technologies, such as stem cells and tissue engineering, to facilitate the renewal of healthy joint tissue and reinstate joint functionality. The exploration of biological therapies and regenerative

*Corresponding author: Biobeid6@hotmail.com (Bilal Mohamad Ali Obeid)

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medicine as potential treatments for joint preservation represents a significant advancement in the field of orthopedics, offering new hope for individuals suffering from joint degeneration or injury. [2]. The significance and importance of biomechanics within the realm of human physiology cannot be exaggerated, as it affords us a comprehensive understanding of the intricate and varied facets of joint operation. Moreover, the knowledge and insights garnered from the study of biomechanics allow us to develop and refine various rehabilitation protocols and physiotherapy techniques that are specifically tailored to optimize and enhance long-term outcomes for individuals who may be experiencing joint-related issues or impairments. [3]. Patient education plays a crucial and indispensable role in the advancement and progress of promoting adherence to rehabilitation protocols, thereby augmenting and enhancing the comprehension and appreciation of the utmost significance and value of joint preservation. [4]. The clinical and functional results, obtained from a comprehensive evaluation of patients' general health and welfare, encompass a comprehensive examination of both the physiological and psychological aspects of their state. These outcomes are meticulously scrutinized and evaluated to comprehensively appraise the efficacy and triumph of interventions intended to safeguard the integrity and functionality of the affected joints. These therapeutic measures are aimed at sustaining the general health and functionality of the impacted joints. Furthermore, the radiological and magnetic resonance imaging (MRI) outcomes, which involve the utilization of advanced imaging techniques to capture detailed images and gather crucial information about the internal structures and functioning of the joints, are meticulously scrutinized and examined to provide a comprehensive understanding of the success and impact of the aforementioned interventions on the joints under investigation. [5]. Orthopedic joint preservation encompasses a variety of specialized techniques aimed at safeguarding the normal operation and structural stability of joints, thereby ensuring their ongoing functionality and structural integrity. The pursuit of such preservation is of paramount significance, as it plays a pivotal role in effectively mitigating the need for subsequent surgical interventions, thereby markedly decreasing reoperation rates, and ultimately contributing to the enhancement and optimization of patient outcomes, both in terms of clinical efficacy and overall wellness. [6]

2. Surgical Techniques for Joint Preservation

Surgical approaches employed for the purpose of preserving joint integrity encompass arthroscopy, osteotomy, and cartilage restoration. Arthroscopy, being a procedure characterized by its limited invasiveness, facilitates the visualization and subsequent treatment of joint maladies, such as cartilage abnormalities. [7]. Osteotomy, a surgical procedure that encompasses the manipulation and repositioning of the skeletal axis, emerges as a paramount intervention to rectify the malalignment, a condition that inevitably fosters the emergence and progression of not only cartilage lesions but also osteoarthritis, thereby underscoring the crucial significance of this therapeutic maneuver in the realm of orthopedics. [8]. It plays a crucial role in enhancing the clinical results of cartilage repair surgeries by optimizing the biomechanical environment of the joint and protecting the repair tissue against overloading [9]. Cartilage restoration techniques encompass autologous surface repair techniques, cell transplantation, and osteochondral graft transplantation, all of which strive to mend or substitute damaged cartilage. [10]. They offer solutions for managing cartilage defects and promoting cartilage regeneration in patients with knee osteoarthritis [11]. These advancements in surgical techniques for joint preservation have the potential to improve outcomes and prevent the progression of osteoarthritis. [12]

2.1. Arthroscopy

Arthroscopy is a minimally invasive technique that allows for better visualization of intra-articular structures and enables a wide variety of joint treatments without the need for traditional open surgery. [13] Arthroscopy of the shoulder, elbow, hip, and knee is increasingly utilized for joint preservation surgical techniques due to advancements in technique, training, and instrumentation. It is generally safe and effective, but the arthroscopist must have a thorough understanding of surgical anatomy, patient positioning, and safe instrumentation portals to prevent neurological injury. In the event of postoperative neurological complications, the physician must carefully document the patient history and physical examination, and consider additional imaging, testing, or surgical nerve exploration with a specialized team depending on the severity of the injury. [14]. It is considered safe and effective, with advancements in technique, training, and instrumentation contributing to its success [15]. Arthroscopy plays a crucial role in surgical techniques for joint preservation by allowing orthopedic surgeons to visualize and treat joint ailments with minimally invasive procedures. The arthroscopist must have a thorough understanding of surgical anatomy, patient positioning, and safe instrumentation portals to prevent neurological injury. [16]

2.2. Osteotomy

Osteotomy is a surgical procedure used to preserve joint function by reorienting and correcting bone deformities, thereby restoring joint congruency and normalizing load transfer. Developmental dysplasia, post-traumatic deformities, and osteoarthritis are frequently encountered clinical scenarios in which this procedure is commonly executed. The goal of osteotomy is to protect damaged cartilage and prevent the progression of joint degeneration. Surgical methodologies for osteotomy differ contingent upon the particular region of the joint necessitating intervention, be it the cartilage layer, subchondral bone, or both. Different types of osteotomies, including high tibial osteotomy (HTO), proximal fibular osteotomy (PFO), and distal femur osteotomy (DFO), have been developed to meet the demands of patients. Osteotomy techniques can achieve the correction of the mechanical axis and result in good functional recovery of the joint. [17, 18]. Osteotomy techniques have evolved over the years, making the procedure reliable, reproducible, and durable. The main target of this surgical procedure is improvement of joint congruency and normalization of load transfer to protect damaged cartilage. [19]. Osteotomy procedures are frequently conducted on the hip joint for the purpose of addressing structural irregularities in the acetabulum and proximal femur, even in cases where severe degenerative alterations are not present. The rationales behind osteotomy entail rectifying deformities in the upper femur, enhancing congruence within the joint, diminishing the likelihood of avascular necrosis, rectifying abnormalities in gait, and managing arthritis that manifests early in life. Proper preoperative planning is crucial, considering factors such as proximal femoral deformity in multiple planes and the overall mechanical axis of the limb. The choice of fixation should be guided by surgical experience and the ability to restore biomechanics. Pelvic osteotomies, such as Salter innominate osteotomy and Pemberton osteotomy, are commonly used procedures for treating developmental dysplasia of the hip in early childhood. However, long-term sequelae such as coxa valga, leg length discrepancy, and hip impingement may occur. Surgical dislocation of the hip presents a secure method for addressing femoroacetabular impingement, offering a comprehensive view of both the acetabular cavity and the surface of the femoral head. [20-23]. In the knee and ankle joints, osteotomy can be used to correct malalignment and redistribute forces, thereby preserving joint function [24]. High tibial osteotomy (HTO) has been shown to result in compensatory changes in the ankle and subtalar joints, suggesting that surgical alteration of the alignment of the proximal tibia can affect distal joints [25]. Mosaic allograft osteochondral transplantation combined with corrective osteotomy has been found to promote the healing of articular cartilage and improve ankle joint function and lower limb alignment in patients with osteochondral lesions of the talus (OLT) [26] The principles of osteotomy involve patient selection, biomechanical knowledge, and clinical examination for correct indications and surgical planning. Radiographic and imaging techniques aid in identifying pathologies and guiding treatment planning. [27]

2.3. Cartilage Restoration

Cartilage restoration techniques aim to preserve joint function and treat cartilage defects. Autologous chondrocyte implantation (ACI) is a commonly used method for cartilage repair. ACI involves harvesting a patient's own chondrocytes, culturing and expanding them in vitro, and then reimplanting them into the cartilage defect. ACI has shown promising results in terms of inducing cartilaginous tissue and providing long-term durability [28]. Autologous chondrocyte implantation (ACI) has evolved over time, with second and third-generation techniques using biomaterials such as collagen membranes to improve outcomes. The first-generation ACI involved using a periosteal patch, which led to the development of the second generation using a collagen membrane instead of periosteum to reduce complications. The third-generation ACI techniques involve seeding autologous chondrocytes onto a scaffold, allowing for a 3-dimensional distribution of cells. These scaffold-based techniques have shown persistently improved clinical outcomes at long-term follow-up, supporting their increasing utilization. The use of collagen membrane-based ACI (ACI-C) has been shown to improve clinical outcomes, reduce treatment failures, subsequent surgical procedures, and graft hypertrophy compared to periosteum-covered ACI (ACI-P). Overall, the evolution of ACI techniques, particularly the use of biomaterials like collagen membranes, has contributed to improved outcomes in the treatment of chondral defects [29, 30]. These advancements have led to more standardized and reliable application of ACI, making it the gold standard for cartilage repair [31]. Clinical studies have shown that autologous chondrocyte implantation (ACI) can lead to good to excellent results in terms of improved knee function and clinical scores, even in high-impact sports athletes. Studies have reported high long-term survival rates and low rates of revision surgery after ACI, indicating its effectiveness as a treatment option for cartilage defects in the knee [32].

Additionally, ACI using next-generation Matrix-Induced Autologous Chondrocyte Implantation (MACI) has been found to be safe and effective in restoring cartilage in the knee joint [33]. Augmented anterior cruciate ligament reconstruction (ACLR) techniques, which can include ACI, have shown high rates of return to sport and low re-injury rates, indicating positive outcomes for athletes [34]. Furthermore, a clinical trial in Japan found that third-generation ACI using IK-01 demonstrated significant improvements in patient-reported outcome measures and knee function, suggesting its effectiveness in treating focal cartilage injuries of the knee [35]. Overall, various surgical techniques, including ACI, have shown promising results in improving knee function and clinical scores in athletes with cartilage injuries. [36]

2.4. Computer-Assisted Surgery (CAS)

Computer-assisted surgery (CAS) plays a significant role in surgical techniques for joint preservation. CAS utilizes computer technology to improve accuracy and safety in corrective procedures on human joints [37]. It offers unique planning software and navigation surgical systems that allow for preoperative identification of hip deformities and planning of surgical corrections using kinematic protocols [38]. Real-time intraoperative 3-D orientation is possible, and surgical corrections can be performed with navigation of surgical tools or printed templates [39]. CAS has shown promising results in the treatment of femoroacetabular impingement, hip dysplasia, hip tumors, and avascular necrosis of the femoral head. It enhances the surgical process by providing quantitative data, measurements, and estimations, leading to improved accuracy, clinical outcomes, and reduced invasiveness [40].

3. Innovative Treatments for Joint Preservation

Innovative treatments for joint preservation, including biological therapies, regenerative medicine, and biomechanics, have gained attention in the field of orthopaedics and sports medicine. These interventions seek to enhance the body's healing capabilities and effectively target musculoskeletal disorders. Biologic treatments incorporate tissue engineering strategies such as cells, scaffolds, and signaling molecules [41]. Orthoregenerative strategies, including blood-derivatives, stem cells, and engineering strategies, have shown promise in modulating and improving the healing response [4]. The articular cartilage of the joint has limited healing capacity, making the repair of cartilage damage challenging. Various treatment modalities, including lifestyle modification, pharmacotherapy, physiotherapy, and osteobiologics, are available for articular cartilage damage [42]. However, conclusive clinical evidence is still lacking, and further research is needed to understand the potential and limitations of these innovative treatments [12].

3.1. Biological Therapies and Regenerative Medicine

3.1.1. Platelet Derivative

Platelet-rich plasma (PRP) and leukocyte- and platelet-rich fibrin (L-PRF) are innovative biological therapies used for joint preservation. PRP is a biological treatment that incorporates tissue engineering strategies, including cells, scaffolds, and signaling molecules, to facilitate the healing mechanism of tissues with limited healing potential such as tendons, cartilage, and ligaments [41]. PRP injections have shown promising clinical results in reducing pain and inflammation, increasing the amplitude of movements, and reducing the intake of painkillers and anti-inflammatory drugs in patients with adhesive capsulitis [43]. L-PRF, made from venous blood drawn from the patient, has regenerative potency, antibacterial capacity, and analgesic activity, making it suitable for use during surgical procedures as a sole biomaterial or as a bioactive additive [44]. Both PRP and L-PRF have shown promising results in various indications and can be used as sole biomaterials or in combination with other natural and synthetic biomaterials. However, while these biological therapies have demonstrated anti-inflammatory properties, no treatment has clearly demonstrated significant joint preservation properties or the ability to reverse the progression of osteoarthritis [12].

3.1.2. Stem Cells

Innovative treatments for joint preservation, including stem cells, are being explored in the field of orthopedic tissue engineering. This approach involves the use of stem cells, such as mesenchymal stem cells (MSCs), which have shown potential for bone and joint tissue regeneration [45]. Tissue engineering strategies incorporate cells, scaffolds, and signaling molecules to facilitate the healing mechanism of tissues with limited healing potential, such as tendons, cartilage, meniscus, and ligaments [41]. Orthoregenerative strategies aim to modulate and improve the body's healing response, and recent research has focused on blood-derivatives, stem cells, biomechanical concepts, and engineering strategies [4]. MSCs have the potential to differentiate into multi-lineage cells and possess immunomodulatory properties, making them a promising therapeutic agent for osteoarthritis (OA) [46, 47]. They can differentiate into chondrocytes, which are the cells responsible for cartilage formation and maintenance, suggesting their potential in cartilage repair and regeneration [48]. Additionally, MSCs have been shown to exert immunomodulatory effects, which can help reduce inflammation in OA joints and promote tissue healing [49]. The use of MSCs in regenerative medicine for OA is supported by their ability to secrete various factors that can modulate the inflammatory environment and promote tissue regeneration [50]. However, further research is needed to fully understand the potential and limitations of these innovative treatments, and conclusive clinical evidence is still lacking [51].

3.1.3. Ozone Therapy

Medical ozone therapy has shown promise as an innovative treatment for joint preservation, particularly in the context of osteoarthritis (OA) and chondropathies. Ozone therapy has been found to have positive results in the treatment of OA, with studies showing pain relief, reduced inflammation, and improved mobility [52, 53]. Ozone therapy has been found to increase chondrogenic differentiation potential and enhance stability of chondrogenesis in human articular chondrocytes (hAC) [54]. Additionally, ozone therapy has been shown to reduce inflammation and decrease levels of pro-inflammatory cytokines, while increasing levels of the anti-inflammatory cytokine IL-10 [55]. The therapeutic effects of ozone therapy are achieved through its antalgic, anti-inflammatory, and antioxidant properties, which include improving tissue oxygenation, enhancing cellular metabolism, and reducing oxidative stress [56]. Additionally, the combination of ozone therapy with other substances such as hyaluronic acid and platelet-rich plasma (PRP) has been found to further enhance joint functional restoration and benefit duration [67]. However, the exact mechanism of action of ozone therapy in joint preservation is not fully understood, and further research is needed to establish its efficacy and long-term effects [58].

3.1.4. Hyaluronic Acid (HA)

Hyaluronic acid (HA) intraarticular injection, in conjunction with minimally invasive surgery, has been shown to be a beneficial therapeutic option for joint preservation [59]. HA has been used for many years as a treatment modality for knee osteoarthritis (OA) and has been found to mitigate joint pain and tissue destruction [60]. Repeated administration of HA injections for osteoarthritis has been shown to provide sustained symptom relief, with pain relief lasting for an average of 466.8 days' post initial treatment [61]. HA has also been found to have disease-modifying effects on the preservation and restoration of the extracellular matrix, making it more than just a simple device for viscosupplementation [62]. Overall, these studies support the use of HA injections as an innovative treatment for joint preservation, particularly in the management of knee osteoarthritis [63].

3.2. Biomechanics

Innovative biomaterials and designs have been developed for joint preservation in orthopaedic surgery. These advancements have led to improvements in the quality, reliability, performance, and versatility of surgical instrumentation and devices [64]. Biomechanical research helps in understanding the behavior of implants in the body and their impact on the patient's tissues [65]. It allows for the optimization of implant design, surface, and connection with abutments, leading to improved biomechanics, increased bone implant contact surface, and better immunological response [66]. Additionally, advanced materials play a vital role in ensuring the success of orthopedic implants by providing the necessary mechanical properties and biocompatibility [67]. The use of biomaterials in orthopaedic implants has grown significantly, driven by advancements in implant designs and materials that provide improved biocompatibility, durability, and expanded clinical applications [68]. Surface modifications, including coatings, have been a key strategy for improving tissue-contacting properties and device-tissue integration [69]. In the field of orthopaedic surgery, metal alloys, high molecular-weight substances, ceramics, titanium, high density polyethylene, and hydroxyapatite have been used in artificial joints, fracture fixations, and other applications [70]. These innovative biomaterials and designs aim to improve biointegration, mechanical strength, flexibility, and compatibility with 3D printing [71].

3.3. Pharmacology

Pharmacology plays a crucial role in innovative treatments for joint preservation. The management options for articular cartilage damage include, pharmacotherapy and various joint preservation techniques [12]. Innovative treatments for joint preservation involve targeting the molecular pathways involved in bone and cartilage remodeling in arthritis These pathways include catabolic pathways such as receptor activator of nuclear factor-kappaB ligand (RANKL)/RANK and cathepsin K, which contribute to erosive disease, and anabolic pathways such as fibroblast growth factor (FGF), which promote the formation of new bone. Other pathways, like hedgehog, can have a dual function in arthritis, leading to either catabolic or anabolic joint remodeling depending on other factors. Future pharmacotherapy aims to target the pathological activity of these molecular pathways to specifically block either catabolic or anabolic joint remodeling in arthritis. By modulating these pathways, it may be possible to develop new therapies that preserve joint function and prevent further damage in arthritic joints. [72]. Lubricin, a compound that inhibits certain enzymes, has been used in pharmaceutical compositions to lubricate joints and inhibit adhesion formation [73]. Pharmacists have an integral role in pain management and treatment, providing counseling on the appropriate use of analgesic agents for musculoskeletal pain and inflammation [74]. Biochemical markers, including neoepitopes, have been used to identify and evaluate the efficacy and safety of osteo- and chondro-protective drugs, aiding in the development of improved clinical trial design and analysis [75].

4. Rehabilitation Protocols

Rehabilitation protocols for joint preservation, including physiotherapy and patient education, play a crucial role in the treatment of various musculoskeletal conditions. These protocols aim to reduce pain, restore muscular trophism and tone, recover range of motion, and improve joint function [76]. In the case of knee osteochondral surgical interventions, rehabilitation is essential to provide a mechanical environment for healing and facilitate the restoration of joint homeostasis [77]. Multi-disciplinary rehabilitation strategies, which combine drug therapy with educational programs, physical training, and apparatus rehabilitation methods, have proven to be effective in the treatment of rheumatic diseases [78]. Additionally, rehabilitation is important in the overall outcome of joint replacement surgery, with the goals of preventing contractures, improving patient education, and strengthening muscles around the joint through controlled exercises [79].

4.1. Physiotherapy

Physiotherapy plays a crucial role in joint preservation. Physiotherapists possess a wide range of scientifically-based clinical skills that can be integrated across a variety of soft tissue knee injuries and surgical contexts [80]. Physiotherapy plays a role in joint preservation by assisting in the rehabilitation and strengthening of the joint. It can help improve joint stability, range of motion, and muscle strength, which are important factors in preserving joint health. Physiotherapy techniques such as exercises, manual therapy, and modalities like ultrasound and electrical stimulation can be used to reduce pain, inflammation, and swelling in the joint, and promote healing and tissue regeneration. Additionally, physiotherapists can provide education and guidance on proper joint mechanics and body mechanics to prevent further joint damage and promote optimal joint function. [81]. They provide advice and instruction on various aspects of physiotherapy practice for conservative and post-surgical rehabilitation of soft tissue knee injuries [82]. This includes basic principles of knee rehabilitation, pain control, effusion control, joint hypomobility, proprioception, and exercise rehabilitation methods [83]. Physiotherapy techniques such as exercises play a crucial role in joint preservation. Weight-bearing exercise improves blood and synovial fluid circulation in the joint, which is important for maintaining the mechanical competence of the joint. Moderate exercise helps maintain the morphologic and functional integrity of articular cartilage by balancing anabolic and catabolic processes. Lack of exercise can lead to joint contracture and disuse changes, while excessive mechanical stresses can cause joint destruction such as osteoarthritis. Therefore, it is highly desirable to have effective and efficient treatments, including physiotherapy techniques, to improve and protect against joint diseases resulting from insufficient or excessive activities. [84]. Physiotherapy techniques such as manual therapy play a role in joint preservation by addressing pain and improving function. Manual therapy involves the use of hands to stretch, mobilize, or manipulate the spinal column, paravertebral structures, or extremity joints [85]. Physiotherapy techniques such as modalities like ultrasound and electrical stimulation play a role in joint preservation. These techniques are used in the different phases of rehabilitation, including pain control, restoring range of motion, restoring strength, neuromuscular retraining, and return to full activity. Ultrasound is a commonly used modality that can help with pain control and tissue healing. Electrical stimulation is another modality that can be used to aid in pain control and muscle strengthening. These modalities, along with other physical therapy techniques, are important in promoting full function and decreasing the likelihood of recurrence of musculoskeletal injuries. [86]. Extracorporeal shockwave treatment (ESWT) is safe and effective for treating musculoskeletal disorders. ESWT includes two types of technical principles: focused ESWT (F-ESWT) and radial pressure waves (RPW). These technologies differ in their approach but both have shown positive outcomes in joint preservation. F-ESWT focuses the shockwaves on a specific area, while RPW delivers shockwaves radially. Both techniques have been found to be effective in treating musculoskeletal disorders, indicating their potential in preserving joint health. [87]. In the treatment of osteoarthritis, both phonophoresis and iontophoresis of dexamethasone have been found to be effective in improving Western Ontario and McMaster University Osteoarthritis Index scores, ambulatory time, and knee range of motion [88]. Physiotherapists also emphasize collaboration and communication between the General Practitioner, surgeon, and physiotherapist as a multi-disciplinary team for optimal clinical effectiveness and outcomes [8].

4.2. Patient Education

Patient education plays a crucial role in joint preservation. It helps to integrate patient and provider perspectives, promote consistency in practice, and increase patient knowledge [89]. However, it is important to ensure that the information provided is at an appropriate reading level and is understandable and actionable [90]. Pre-operative education, including written material, videos, and individual interaction with health professionals, is valued by patients and can assist in their rehabilitation post-surgery [91]. Engaging patients in managing their healthcare, through classes and addressing their physical, social, and psychological needs, can promote patient engagement and improve quality of life [92]. Overall, patient education in joint preservation should be comprehensive, timely, and tailored to the individual patient's needs, with a focus on realistic recovery processes and ongoing support [93].

5. Long-Term Outcomes

These outcomes provide valuable information about the success of joint-preserving therapies and the need for further interventions. Clinical and functional outcomes assess patient satisfaction, quality of life, and implant survival [94]. Radiological and MRI outcomes help evaluate the structural integrity of the joint and identify any complications such as nonunion or heterotopic ossification [95]. Reoperation rates indicate the need for additional surgical interventions and can be used as a measure of treatment effectiveness [96].

5.1. Clinical and Functional Outcomes

Patient satisfaction, pain relief, and functional improvement were evaluated in several studies. One study examined patient satisfaction in an interdisciplinary pain management program and found that integrating satisfaction measures with pain-related variables highlighted global change and improvement from the patients' perspective [97]. Another study focused on chronic intractable pain and found that treatments like physical therapy, interventional pain procedures, and spinal cord stimulation (SCS) resulted in acceptable patient outcomes [98]. A retrospective observational study evaluated the clinical results of endoscopic lesser trochanter resection in patients with ischiofemoral impingement and found that the procedure provided satisfactory outcomes with symptom relief and good functional results [99]. A prospective study on patellofemoral inlay arthroplasty showed high patient satisfaction with significant improvement in knee function and pain relief after mid-term follow-up [100]. Understanding patients' perspectives on pain and function is important for identifying avoidable problems, informing prognostic expectations, and identifying potential interventions to improve outcomes. Studies have shown that patients' experiences of recovery after surgery often differ from their expectations, and the challenges of pain and its impact on function can be difficult to navigate. Ongoing problems with pain, function, and mood can take a toll on patients, leading to the need to "endure." The importance of clinical and social interactions on mood and pain has also been highlighted. Tailoring the approach to address these individual considerations from the patient perspective could lead to improved success. [101].

5.2. Radiological and MRI Outcomes

Imaging techniques such as computed tomography arthrography (CTA) and magnetic resonance arthrography (MRA) are used to evaluate early degenerative changes in the hip and to assess joint preservation success [102]. These modalities have become routine practice in the evaluation of joint replacements, including hip, knee, shoulder, elbow, and ankle replacements [103]. Different modalities have been used to assess implant osseo-integration, septic and aseptic loosening, and adverse tissue reactions. However, there is a lack of standardization and validity in these techniques. Each imaging modality has its own role depending on the required information and anticipated outcomes. Plain radiographs are recommended for suspected peri-prosthetic joint infections, while ultrasound and plain radiographs can serve as initial screening tools for aseptic loosening. Metal artifact reducing sequences (MARS) MRI are advancing cross-sectional imaging and are likely to have a greater role in patient evaluation. Close collaboration between radiologists and orthopaedic surgeons is essential for optimal patient care [104]. Advances in imaging technology have improved the diagnosis of post-operative complications in knee and hip arthroplasty, articular cartilage repair, and high tibial osteotomy [105]. The choice of imaging technique should consider the information required, availability, accessibility, expertise, and costs [106].

5.3. Reoperation Rates

Reoperation rates can be used as a measure of treatment effectiveness in joint preservation procedures [107]. Unplanned reoperations within 30 days of the initial surgery are often indicators of complications or the need for additional interventions [108, 109]. These reoperations can provide valuable information about the quality of surgical care and identify areas for improvement [110]. Factors such as infections, mechanical complications, and poor functional status have been associated with higher reoperation rates [111]. Monitoring reoperation rates and understanding the reasons behind them is crucial for assessing surgical outcomes and implementing strategies to prevent complications and improve patient care. Adams et al. found that focusing only on reoperations within 30 days of the initial operation captures only a fraction of unplanned reoperations [108]. Rammohan et al. emphasized the role of care transition teams in reducing hospital readmission rates and easing the financial strain on healthcare institutions [112]. Edden and Reissman argued that the rate of complications should not be the sole parameter for assessing surgical performance, and that the time frame for diagnosing a post-operative problem and the clinical approach taken should also be considered [113]. Karakitsos et al. discussed the importance of perioperative monitoring in improving patient outcomes and highlighted the potential of ultrasound technology in this regard [114].

6. Conclusions

In conclusion, this comprehensive review article has provided a detailed analysis of orthopedic joint preservation, covering surgical techniques, innovative treatments, rehabilitation protocols, and long-term outcomes. The article has discussed various surgical techniques used in joint preservation, highlighting their indications, outcomes, and potential complications. It has explored innovative treatments, such as regenerative medicine and stem cell therapy, and their role in promoting joint preservation and tissue healing. Rehabilitation protocols for joint preservation have been examined, emphasizing the importance of early mobilization, physical therapy, and patient education in optimizing outcomes. The review article has also evaluated the long-term outcomes of joint preservation procedures, including functional outcomes, pain relief, and patient satisfaction, providing insights into the effectiveness and durability of these interventions. Overall, this comprehensive analysis serves as a valuable resource for orthopedic surgeons, researchers, and healthcare professionals involved in the management of joint disorders, offering evidence-based information to guide decision-making and improve patient outcomes in the field of orthopedic joint preservation.

Abbreviations

MRI: Magnetic Resonance Imaging.
HTO: High Tibial Osteotomy.
PFO: Proximal Fibular Osteotomy.
DFO: Distal Femur Osteotomy.
OLT: Osteochondral Lesions of the Talus.
ACI: Autologous Chondrocyte Implantation.
ACI-C: Collagen Membrane-Based ACI.
ACI-P: Periosteum-covered ACI.
MACI: Matrix-Induced Autologous Chondrocyte Implantation.
ACLR: Augmented Anterior Cruciate Ligament Reconstruction.
IK-01: CaReS™ is a third generation ACI product developed by Arthro Kinetics Biotechnology GmbH in Austria. In the CaReS system, isolated chondrocytes are cultured on a matrix based on type I collagen from rat tails for 2 weeks and then surgically attached to the cartilage defect with fibrin glue.

Its unique characteristics are the three-dimensional culture of chondrocytes without a monolayer culture to decrease the change toward the fibroblastic phenotype the product code name was IK-01 in this clinical trial.

CAS: Computer-Assisted Surgery.

PRP: Platelet-Rich Plasma.

L-PRF: Leukocyte- and Platelet-Rich Fibrin.

MSCs: Mesenchymal Stem Cells.

OA: Osteoarthritis.

hAC: human Articular Chondrocytes.

IL-10: Interleukin 10.

HA: Hyaluronic Acid.

RANKL: Receptor Activator of Nuclear Factor-Kappa B Ligand.

RANK: Receptor Activator of Nuclear Factor-Kappa B.

cathepsin K.: is a proteinase that is secreted by osteoclasts and results in bone degradation, primarily of type I collagen.

FGF: Fibroblast Growth Factor.

ESWT: Extracorporeal Shock Wave Treatment.

F-ESWT: Focused ESWT.

RPW: Radial Pressure Waves.

SCS: Spinal Cord Stimulation.

CTA: Computed Tomography Arthrography.

MRA: Magnetic Resonance Arthrography.

MARS: Metal Artifact Reducing Sequences.

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Author Contributions

Bilal Mohamad Ali Obeid is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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