Clinical Decision-Making in Total Hip Arthroplasty: Evaluating Indications and Alternatives

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Abstract. Total hip arthroplasty (THA) is widely regarded as the gold standard for the treatment of end-stage hip disease, yet not all patients require or are suitable for immediate surgery. For those with mild to moderate disease, particularly younger and more active individuals, alternative strategies such as hip arthroscopy, osteotomy, and intra-articular injections can provide symptomatic relief, delay disease progression, and preserve native joint function whenever possible. These approaches have gained attention in recent years as they may postpone the need for THA and reduce the risk of early revision in high-demand patients. However, for advanced disease with irreversible structural damage, THA remains the definitive option. Optimal decision-making requires careful integration of clinical symptoms, radiographic evidence, patient age, comorbidity profile, personal preference, surgical techniques, and perioperative risk assessment. This review aims to systematically summarize the indications and limitations of alternative treatments, explore the criteria for THA candidacy and the selection of surgical timing, and evaluate the contribution of predictive models and decision-support tools to clinical decision-making, with the goal of providing references for individualized management.

Keywords: Total hip replacement, osteoarthritis, alternative treatments.

1. Introduction

Hip disease is one of the important causes of chronic pain and dysfunction with common etiologies including osteoarthritis (OA), femoral neck fractures, femoral head necrosis, and developmental hip dysplasia. These conditions can significantly limit mobility, reduce quality of life, and increase the risk of disability and mortality [1]. As global populations age and life expectancy continues to rise, the prevalence of hip diseases is escalating, placing continuous strain on public health systems and socioeconomic structures [2].

Traditional conservative treatment strategies, such as pharmacotherapy, physical rehabilitation, and intra-articular injections, offer some relief in terms of pain management and functional improvement. However, these interventions cannot halt the progressive structural degeneration of the hip joint. For certain younger patients, hip-sparing surgeries, including hip arthroscopy and osteotomy, may provide benefits, but their scope is limited and long-term outcomes remain suboptimal [3]. Consequently, for individuals with end-stage hip disease, conservative treatments and joint-preserving options often fail to meet the need for durable functional restoration. In this context, total hip arthroplasty (THA) has emerged as the definitive surgical intervention for advanced hip disease. THA has demonstrated exceptional efficacy in pain relief and functional recovery, making it one of the most widely performed and well-established orthopedic procedures globally, with over 1 million hip replacements conducted annually in the United States alone [4]. By 2014, nearly 400,000 joint replacements were performed in China, 60% of which were hip replacements [5]. In 2018, France reported a total of 183,139 hip surgeries, including 148,965 primary hip replacements and 19,304 revision procedures. Projections suggest that the number of primary hip replacements will increase by 41.9% to 114.3% from 2018 to 2050 [6]. In the United States, the total number of joint replacements increased by 18.3% between 2020 and 2021, with 866,410 primary hip replacements recorded from 2012 to 2020 [7]. These statistics underscore the rising demand for hip replacement surgeries worldwide.

Despite significant advancements in prosthetic technology and surgical techniques, THA remains associated with certain risks, including adverse outcomes and complications. The frequency of revision surgeries is on the rise, with associated increases in complication rates, morbidity, and mortality compared to initial procedures. These challenges impose substantial psychological and financial burdens on patients. While national fee control measures, such as NCP and NVBP, have led to a reduction in hospitalization costs and implant prices, the burden of THA revisions continues to strain healthcare systems [2]. This review aims to systematically examine the indications for THA, analyze the timing of surgery with particular attention to early intervention compared with conservative management, and appraise the potential and limitations of alternative strategies such as hip arthroscopy, osteotomy, and intra-articular injections.

2. Conservative Treatment

Conservative treatment is an important means of treating mild to moderate hip disease. For patients who cannot undergo surgery and can delay surgery in the early stages. Conservative treatment plays an important role. Common conservative treatments include medication, physical therapy, and intra-articular injections. While these methods are effective in relieving symptoms, their effects are often temporary and do not alter the structural damage to the hip joint. Therefore, conservative strategies should be viewed as transitional measures rather than definitive solutions in the long-term management of hip disease.

2.1. Pharmacological Treatment

Pharmacological management of hip osteoarthritis commonly involves nonsteroidal anti-inflammatory drugs (NSAIDs), opioids, and acetaminophen. A meta-analysis indicated that diclofenac 150 mg/day and etoricoxib 60 mg/day were the most effective oral NSAID regimens for analgesia, although they were also associated with a higher likelihood of treatment discontinuation due to adverse events. Topical diclofenac (70–81 mg/day) is highly effective and safer and is recommended as a first-line agent for osteoarthritis. Opioids have not shown significant clinical benefit at any dose, and the risk of adverse events and discontinuation is significantly higher. It should only be used for severe pain when other medical treatments are ineffective and under strict monitoring. Acetaminophen is the weakest effect. Research supports prioritizing topical NSAIDs and avoiding long-term or high-dose opioids [8]. However, the heterogeneity of serious adverse events in the study is large. The patients with comorbidities are underrepresented and the follow-up time is short. Long-term safety still needs to be considered.

2.2. Physical Rehabilitation

Physical rehabilitation should be judged based on the key hip lesions on imaging. The efficacy of physiotherapy, including heat therapy, ultrasound, and electrical stimulation, for the treatment of hip osteoarthritis pain was evaluated in one study. An analysis of 23 randomized controlled trials encompassing 30 treatment protocols and 1055 participants reported that half of the interventions achieved the minimal clinically important difference, defined as a 20% reduction in pain scores on visual analogue scales, although no significant differences were observed between modalities. Sequential treatment guidelines proposed by Jean-Philippe Paul Berteau emphasize that individualized strategies and multimodal combinations, including integration with exercise therapy, are central to optimizing the management of osteoarthritis pain. Initial use of electrical stimulation (TENS) to control pain, followed by two weeks of ultrasound (CU) therapy. It can be combined with deep microwave therapy (MD) for long-term management with pulsed electrical stimulation (PES) for maintenance [9, 10]. However, there is limited evidence for hip osteoarthritis in research. It is recommended to attempt ultrasound with caution and further explore the possibility of spinal nerve stimulation. In summary, physical therapy has a certain effect on relieving the pain of hip

osteoarthritis, especially in the short term. However, the efficacy varies greatly, and more research and verification are still needed for long-term efficacy and personalized treatment needs.

2.3. Intra-articular Injections

Intra-articular injections are a proven and widely used treatment for patients with mild to moderate hip osteoarthritis. A web-based meta-analysis of 57 large RCTs involving 22,795 patients with knee or hip osteoarthritis evaluated 18 intra-articular interventions. The analysis showed that triamcinolone acetonide, a corticosteroid, was the only agent that consistently provided short-term pain improvement over 2 to 6 weeks (SMD -0.48 to -0.53) with a probability of 75.3% to 90%. The combination homeopathic preparation Tr14/Ze14 also demonstrated potential efficacy at 6 weeks (SMD -0.42). There was no statistical difference in hyaluronic acid (HA) efficacy from placebo (SMD: -0.04), but there was a higher risk of withdrawal from adverse events (OR: 2.01). The remaining 16 interventions showed no sustained clinical benefit, evidence of long-term effectiveness was lacking, and efficacy was mostly consistent with placebo effects.

Another meta-analysis reported that prior intra-articular injections were associated with an increased risk of periprosthetic joint infection (PJI) following total hip arthroplasty (RR 1.38, 95% CI 1.01–1.87), with the highest risk observed within 3 months after injection (RR 1.64). Risk remains significant after sensitivity analysis excludes studies with large heterogeneity (RR: 1.20). However, at least 3 months between injections and surgery can reduce the risk of infection. It is recommended to ask about the injection history and inform the patient about the associated risks before surgery [3]. However, the diagnostic criteria for PJI in this study are not uniform, and some studies do not clearly define PJI, which may affect the comparability of results.

A clinical trial evaluated nanosurgical and bioengineered regenerative protocols (NSBTs) for hip osteoarthritis. In this double-blind randomized controlled study, 38 patients were assigned to either an NSBT group, which received modified platelet-rich plasma combined with growth hormone and *Strophanthus kombe* extract, or a control group treated with non-standardized PRP. Patients in the NSBT group experienced a marked reduction in pain, with mean VAS scores decreasing from 7.8, indicative of severe pain, to 0.2, corresponding to minimal discomfort. Functional outcomes also improved substantially, as reflected by a decline in WOMAC scores from 76.2, consistent with severe disability, to 10.5, indicative of only mild limitation. Range of motion was enhanced, and no serious treatment-related adverse events were reported [11]. Therefore, NSBT is considered a safe and effective non-surgical alternative that significantly relieves symptoms, improves function, and may delay or avoid THA. It is recommended to further verify its long-term efficacy and generalization ability through studies with larger samples and longer follow-up periods.

3. Hip-Preserving Surgical Options

3.1. Hip Arthroscopy

Hip arthroscopy (HA) is an effective and innovative procedure with rapidly expanding indications. Common indications include femoroacetabular impingement (FAI), trochanteric pain syndrome, hip fracture disease, and cartilage damage. In recent years, with the gradual popularization of surgical techniques, the average improvement values of hip arthroscopic surgery were 34.82, 30.46 and 26.21 points in 2005-2014, 2015-2017 and 2018-2019, respectively ($p<0.00001$). Fewer postoperative complications and faster recovery [12]. However, this technology has technical challenges such as a steep learning curve and intraoperative traction risks. Efficacy data are lacking for long-term treatment. A systematic review of 16 studies (2278 patients with hip disease) compared the effects of HA versus non-surgical treatment on the progression of hip osteoarthritis (OA) in patients with femoroacetabular impingement syndrome (FAIS). The results showed that HA reduced the risk of progression of radiographic OA by 32% ($P=0.002$) at long-term follow-up (>10 years), but did not significantly reduce the risk of conversion to total hip arthroplasty (THA). The rate of OA progression increases with the duration of follow-up [13]. Therefore, HA may delay the progression of OA

imaging in patients with FAIS, but it has not significantly reduced the conversion rate of THA. More high-quality long-term studies are still needed to verify its efficacy.

3.2. Osteotomy

Ilizarov hip reconstructive osteotomy (IHR) is a joint-preserving procedure applied in young patients with chronic painful hip instability. Indications include advanced structural damage such as developmental dysplasia, post-infectious sequelae, and pseudarthrosis. This procedure provides pelvic support through a proximal valgus osteotomy. Distal varus osteotomy corrects the mechanical axis and lengthens the limb. It is beneficial for improving gait, reducing pain, and reducing lameness. Compared with total hip replacement, IHR has the advantages of no joint replacement, better mobility, and low revision requirements. However, there are complications such as needle tract infection, knee stiffness, and bone nonunion [14]. Therefore, IHR is considered an effective salvage option in young patients, especially when total hip replacement is contraindicated. Osteotomy reduces the need for revision and maintains better joint mobility compared to hip replacement.

4. Total Hip Arthroplasty

Conservative treatment should be prioritized before THA is considered as a definitive treatment. In younger patients, THA significantly reduces pain and improves function, but its revision rate is much higher than in older patients [15]. Therefore, hip-sparing surgery should be tried as a priority for treatment. However, patients should be advised that eventual THA may be required as the disease progresses. THA is considered the ultimate choice after all joint sparing procedures have failed or failed. In older patients, excessive delay in surgery leading to an increased risk of perioperative complications should be avoided. Delaying surgery may not only lead to worsening symptoms, but may also increase the difficulty of surgery and the risk of complications due to aggravation of joint damage.

4.1. Indications for THA

In the clinical treatment of hip joint diseases, how to reasonably judge the urgency of surgery is an important issue. For some acute diseases, delaying surgery can lead to worsening complications and even endangering the patient's life. The American Academy of Orthopaedic Surgeons (AAOS) defines categories of urgency for total hip arthroplasty. Time-limited procedures encompass hip fractures such as femoral neck fractures, rapidly progressive femoral head collapse due to avascular necrosis or tumor, progressive bone erosion from conditions including malignancy, severe osteoporosis, or periprosthetic osteolysis, failure of internal fixation with nonunion or implant loosening, recurrent prosthesis dislocation causing marked functional limitation, and periprosthetic joint infection requiring early debridement to preserve the implant. Delayed surgery for hip fractures is associated with increased one-year mortality rates of 14 to 36 percent, whereas early intervention reduces the risk of complications and death. Rapid bone erosion or loosening of the prosthesis can lead to more complex reconstructive surgery and a higher risk of complications if left untreated. Delayed treatment of periprosthetic infections can progress from debridement to retained prostheses to more complex two-stage revisions, increasing patient pain and risk. Acute surgery includes acute periprosthetic infection (PJI), non-replaceable prosthetic dislocation, periprosthetic fracture with severe dysfunction or neurovascular injury. These conditions, if not treated immediately, can lead to the spread of infection, soft tissue damage, neurovascular damage, and even death. Delayed treatment of acute infection may result in loss of prosthesis-sparing opportunities and require a more complex and more complicated two-stage revision [15].

4.2. Benefits and Limitations of Early Surgery

The timing of early surgery is critical in the management of hip disease. Prompt intervention can shorten exposure to bleeding inflammation and severe pain thereby lowering perioperative risk. A

large retrospective cohort study of 146,754 patients undergoing total hip arthroplasty or hemiarthroplasty for femoral neck fractures between 2013 and 2019 reported that fewer than 20% received surgery within 48 hours of admission. After propensity score matching, early total hip arthroplasty was associated with lower rates of pulmonary embolism, deep vein thrombosis, transfusion, and 30-day readmission. Early hemiarthroplasty showed comparable benefits with fewer venous thromboembolism related readmissions [16]. Additional evidence indicates that modern THA prostheses provide favorable long-term outcomes in younger patients, including improved implant survival and enhanced quality of life [17]. Nevertheless, the higher revision rate in this group highlights the importance of careful prosthesis selection, particularly with respect to fixation method, polyethylene quality, and bearing surfaces such as ceramic-on-ceramic or ceramic-on-polyethylene [18].

4.3. Predictive Models and Decision-Support Tools in THA

Preoperative risk stratification of THA patients can help physicians identify high-risk patients to optimize perioperative management. Provide patients with more personalized intervention strategies. A study builds a prediction model based on five machine learning algorithms (random forest, gradient boosting, support vector machine, neural network, and elastic network regression).To identify whether patients with THA achieve a minimal clinically important difference (MCID) in patient-reported health status (PRHS) after surgery. Preoperative data (age, body mass index, smoking history, number of comorbidities, etc.) were used to predict the achievement of MCID. Individual risk prediction and personalized preoperative intervention for the patient. The results show that the random forest algorithm shows excellent prediction performance and clinical practicability in independent test sets, especially in terms of discriminant ability (AUC=0.97) and Brier score (0.054) significantly better than other models [19]. However, its data source is relatively single, mainly for the first THA, and there is a lack of data on the revision of THA. In the revision population, in addition to routine clinical factors, factors such as prosthesis infection, prosthesis age, and prosthesis material should be included in the model. To improve the accuracy and generalization of predictions.

5. Conclusion

Clinical decision-making for THA is a multifactorial and complex process. It involves an intricate combination of factors including symptoms, imaging results, patient age, comorbidities, patient preferences, surgical technique selection, and thorough risk assessment. For mild-to-moderate cases, conservative treatments such as medications, physical rehabilitation, and intra-articular injections may offer short-term symptom relief. Hip-sparing procedures, such as arthroscopy and osteotomy, can help delay disease progression in younger patients; however, the long-term efficacy of these interventions remains uncertain. Therefore, when structural damage becomes apparent or functional impairment is severe, THA continues to be the most reliable treatment option. The timing of surgery plays a pivotal role in determining prognosis. Premature intervention may increase the likelihood of revision surgery, while undue delay can lead to complications and irreversible functional deterioration. Surgical decision-making varies across different patient populations, with younger patients focusing on prosthesis longevity and revision rates, while older patients may need to consider the risks associated with delays in surgery, which could increase perioperative complications.

The integration of predictive models and decision support tools in THA clinical practice is gradually advancing. By stratifying patients based on their individual characteristics, these tools are expected to provide clinicians with more precise guidance, optimizing surgical decisions and enhancing preoperative communication with patients regarding the risks and benefits of treatment. However, current models predominantly focus on primary surgeries and have not yet been validated or expanded to include revision cases. Future research should aim to refine the risk assessment system, incorporating more factors related to disease complexity and long-term recovery. It is essential to develop decision-making tools that directly align with clinical workflows. By combining evidence-

based medicine with intelligent technologies, the clinical management of THA is poised to become more scientifically grounded and individualized, ultimately improving patient outcomes.

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