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TREATMENT STRATEGIES FOR AVASCULAR NECROSIS OF THE FEMORAL HEAD: A SYSTEMATIC REVIEW

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ABSTRACT

Introduction: Avascular necrosis of the femoral head (ANFH) is a progressive condition caused by impaired blood supply to the subchondral bone, leading to femoral head collapse, cartilage damage, and secondary hip osteoarthritis. Major risk factors include corticosteroid therapy, trauma, and chronic alcohol consumption. ANFH primarily affects young, active adults aged 20–40 years. MRI is essential for early diagnosis. Early detection allows hip-preserving treatment, whereas advanced disease often requires total hip arthroplasty. Without appropriate treatment, secondary degenerative changes may develop in 70–80% of patients.
Aim of the study: The aim of this review was to assess the current evidence regarding the treatment of avascular necrosis of the femoral head, with particular emphasis on non-surgical and hip-preserving surgical treatment options. The review evaluates their clinical and radiographic outcomes, effectiveness in preventing disease progression and delaying total hip arthroplasty, and identifies the most appropriate treatment strategies according to disease stage.
Methods and materials: We reviewed the literature available in the PubMed database using the following keywords: "Avascular necrosis of the femoral head"; "Non-surgical treatment"; "Bisphosphonates"; "Statins"; "Iloprost"; "Hyperbaric oxygen therapy"; "Core decompression"; "Osteotomy"; "Nonvascularized bone graft"; "Vascularized bone graft"; and "Total hip arthroplasty".
Conclusion: The treatment of avascular necrosis of the femoral head should be tailored to disease stage and patient characteristics. Early diagnosis is crucial for enabling joint-preserving treatment and delaying disease progression. Pharmacological therapies may benefit selected patients, although their efficacy remains inconclusive. Hip-preserving surgery shows promising results, particularly in early-stage ANFH. In advanced disease with femoral head collapse, total hip arthroplasty remains the most effective treatment, improving pain, hip function, and quality of life.

KEYWORDS

Avascular Necrosis of the Femoral Head, Non-Surgical Treatment, Surgical Treatment

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1. Introduction

Avascular necrosis of the femoral head (ANFH) is a disease characterized by apoptosis of bone marrow cells and osteogenic cells, which subsequently leads to collapse of the femoral head and secondary damage to the overlying articular cartilage. The lesions caused by the disease may result in secondary osteoarthritis of the hip (Guerado & Caso, 2016). In the United States, approximately 25,000 patients undergo total hip arthroplasty annually due to the consequences of avascular necrosis of the femoral head, indicating its significant contribution to the development of hip osteoarthritis (Seijas, Sallent, Rivera & Ares, 2019). The pathogenesis of ANFH is associated with impaired blood supply to the subchondral bone. The most important risk factors include prolonged or high-dose corticosteroid therapy, fractures, hip dislocation, and chronic alcohol consumption. Due to its high sensitivity, magnetic resonance imaging (MRI) is considered a key diagnostic modality for early detection, as it enables the identification of characteristic changes before they become visible on conventional radiographs (Leonhardt & Wörtler, 2026). The disease most commonly affects relatively young and physically active individuals between 20 and 40 years of age and is characterized by a progressive course leading to significant impairment of joint function. (Mankin, 1992). Early diagnosis of avascular necrosis of the femoral head enables the use of treatment methods other than total hip arthroplasty (THA). In the absence of appropriate treatment, the disease may progress and lead to the development of secondary degenerative changes in the hip in 70–80% of patients (Tripathy, Goyal & Sen, 2015). Treatment options include pharmacological therapy, including the use of bisphosphonates and statins, physical modalities, and surgical treatment aimed either at preserving or replacing the hip joint. Surgical treatment can be divided into femoral head–sparing procedures (FHSP) and femoral head replacement procedures (FHRP). In the early stages of the disease, before femoral head collapse occurs and when symptoms are mild, joint-preserving procedures are preferred. In contrast, in advanced, symptomatic stages of the disease, procedures involving replacement of the femoral head are more commonly performed (Moya-Angeler, Gianakos, Villa, Ni & Lane, 2015).

2. Description of the State of Knowledge

Non-Surgical Treatment Approaches

One of the treatment modalities for ANFH is pharmacotherapy, which includes bisphosphonates, statins, vasodilators, and anticoagulants. Due to its limited efficacy, pharmacological treatment is generally used in the early stages of the disease (Konarski et al., 2022).

Bisphosphonates

Bisphosphonates may delay femoral head damage and prevent femoral head collapse by inhibiting bone resorption, primarily through their effects on osteoclasts (Roth et al., 2016). The efficacy of alendronate was compared with that of placebo in patients with ANFH classified as Steinberg stage II–III. In a randomized controlled trial, 40 patients were divided into two groups, with one group receiving 70 mg of alendronate once weekly and the other serving as the control group. Based on the incidence of femoral head collapse and the need for hip arthroplasty among the study participants, the authors concluded that alendronate might delay or prevent early femoral head collapse (Lai et al., 2005). In a prospective observational study, 45 patients received 10 mg of alendronate once daily for a period of 10 years. Three years of pharmacological treatment demonstrated a long-term beneficial effect on the course of ANFH, which persisted for up to 10 years of follow-up. During alendronate treatment, inhibition of the progression of radiographic changes, a reduction in the risk of femoral head collapse, and a decreased need for surgical treatment, including hip arthroplasty, were observed (Agarwala & Shah, 2011). A two-year, multicenter, prospective, randomized, double-blind study evaluated 52 patients with ANFH classified as Steinberg stage IIC or IIIC. In the placebo group, 5 patients involving 33 hips required total hip arthroplasty (THA), whereas in the alendronate group, THA was performed in 4 patients involving 32 hips. Treatment efficacy was also assessed using the Harris Hip Score (HHS) and the Short Form-36 (SF-36) questionnaire. No significant advantage over placebo was demonstrated in preventing the progression of femoral head lesions or with regard to changes assessed by imaging studies, including radiography and magnetic resonance imaging (MRI). The study found no significant differences between the two groups in the frequency of THA, improvement in hip function, or quality of life (Chen et al., 2012). A meta-analysis of randomized controlled trials was conducted to assess improvements in HHS, the frequency of THA, and the progression of femoral head collapse. Across five studies involving a total of 329 patients, bisphosphonates did not demonstrate a significant improvement in clinical outcomes compared with

placebo. Based on this analysis, the routine use of bisphosphonates in the treatment of ANFH is not recommended, and their use should be limited due to the potential for serious adverse effects (Yuan, Guo & Yan, 2016). In contrast, a systematic review including eight studies with short- and long-term follow-up found that patients treated with bisphosphonates achieved more favorable clinical and radiological outcomes compared with untreated control groups. The findings of this analysis suggest that alendronate may be considered as a treatment option for ANFH, particularly in the early stages of the disease. However, future studies should focus on determining the optimal treatment regimen, patient-related factors, and precise indications for the treatment of ANFH. Large, multicenter, randomized, double-blind clinical trials are therefore needed to clearly determine the efficacy of this therapy in patients with ANFH (Luo, Lin, Zhong, Yan & Wang, 2014).

Statins

Long-term corticosteroid use can lead to hyperlipidemia, which may subsequently result in an increased accumulation of fat within the femoral head and, consequently, bone necrosis. Statins are intended to reduce lipid concentrations in tissues and throughout the body by influencing lipid metabolism (Pritchett, 2001). The effect of statin use was investigated in patients receiving corticosteroid therapy following kidney transplantation. In a retrospective cohort study involving 2,881 patients, osteonecrosis occurred in 4.4% of patients, compared with 7% among those who did not receive statin therapy. The results showed that statins did not provide a significant protective effect, as the difference was not statistically significant ($p = 0.14$) (Ajmal, Matas, Kuskowski & Cheng, 2009).

Vasodilators

One representative of this group is iloprost, which has shown promising results in the short-term treatment of early-stage ANFH and bone marrow edema (Disch, Matziolis & Perka, 2005). A total of 108 patients with 136 painful lesions of bone marrow edema or radiologically diagnosed features of osteonecrosis were retrospectively identified and followed. The patients were treated with iloprost, and in 31 cases, pharmacological treatment was combined with surgical intervention. The results showed that iloprost treatment led to improvement in symptoms and pain reduction in 74.8% of cases, suggesting that pharmacological therapy may be an effective treatment option, particularly in the early stages of ANFH (ARCO stages 1–2) (Claßen et al., 2016).

Hyperbaric Oxygen Therapy (HBO)

A prospective study conducted between 2010 and 2018 collected data from 15 patients with non-traumatic osteonecrosis of the femoral head classified as Steinberg stage I–II. All patients had the diagnosis confirmed by MRI and underwent 25–40 sessions of hyperbaric oxygen therapy (HBO), at a frequency of 3–4 sessions per week, with follow-up for at least one year. The results showed satisfactory outcomes in 86.7% of the patients, with a mean Oxford Hip Score of 37.3 points and a reduction in pain as assessed using the visual analogue scale (VAS). However, femoral head collapse progressed in 4 patients, indicating that disease progression may occur despite clinical improvement. Therefore, the appropriateness and efficacy of this treatment require further investigation (Salameh, Moghamis, Kokash & Ahmed, 2021).

Surgical Treatment

Core Decompression of the Femoral Head

This procedure involves drilling channels into the femoral head in patients with ANFH with the aim of restoring blood flow, reducing intraosseous pressure, and relieving pain (Sen, 2009). A study was conducted to evaluate the effectiveness of core decompression (CD) of the femoral head using multiple small channels created with a 3-mm Steinmann pin. The results showed that 71% of patients undergoing the procedure achieved satisfactory clinical outcomes, with the greatest efficacy observed in patients with stage I disease. Based on these findings, core decompression may be a suitable treatment option for patients in the early stages of the disease, with the aim of delaying the need for total hip arthroplasty (THA) (Mont, Ragland & Etienne, 2004). Core decompression has been shown to achieve more than 76% radiological survival at two years after the procedure, as well as improvements in clinical outcomes, demonstrating the potential of this method to delay disease progression, particularly in patients with early-stage ANFH. Furthermore, more than 72% of patients avoided THA two years after core decompression (Vega, Cervantes, Yee & Nho, 2026). In 2021, a scoping review of the literature available in PubMed, Google Scholar, and Scopus analyzed 11 studies involving 612 hips treated with core decompression combined with bone marrow aspirate concentrate (BMAC).

Patients were followed for periods ranging from 2 to 12 years, and the severity of ANFH ranged from stage I to IV. The results showed that the majority of cases demonstrated clinical improvement, whereas radiological progression occurred in 23.5% of hips and 14.9% of hips required THA. Based on these findings, the procedure may provide clinical benefits and reduce the risk of radiological disease progression and the need for more invasive surgical procedures (Pawar, Vaish & Vaishya, 2021). A pooled analysis of core decompression performed without augmentation, including a total of 1,134 hips, demonstrated overall improvement in clinical scores in 24 of 37 studies, while 9 studies reported only partial improvement. It was also observed that 38% of patients required conversion to total hip arthroplasty after a mean follow-up period of 26 months (Andronic, Weiss, Shoman, Kriechling & Khanduja, 2021).

Osteotomy

Two main types of osteotomy are used in the treatment of ANFH: rotational transtrochanteric osteotomy and angular intertrochanteric osteotomy. Both procedures aim to remove or reposition the necrotic portion of the femoral head to reduce the load on the affected area (Dean & Cabanela, 1993; Langlais & Fourastier, 1997). The effectiveness of this method was reported in a study involving 41 hips treated with anterior rotational transtrochanteric osteotomy of the femoral head, in which preservation of the articular surface and prevention of further femoral head collapse were achieved. Despite these promising results, further studies with long-term follow-up are required to confirm the efficacy of this method (Sugioka, 1978). An eight-year follow-up study was conducted in 35 hips of 28 young patients treated with posterior rotational osteotomy of the femoral neck. Data were collected retrospectively. The results showed that further femoral head collapse was prevented in 94% of hips, while an adequate amount of viable bone was maintained in the weight-bearing portion of the joint. The method was also found to be effective in delaying joint degeneration, as assessed by the progression of joint-space narrowing (Atsumi, Kajiwara, Hiranuma, Tamaoki & Asakura, 2006). An analysis of 16 articles involving 775 patients who underwent a total of 852 osteotomies, including rotational transtrochanteric, valgus-flexion, and half-wedge osteotomies, was performed. This procedure may be an effective joint-preserving treatment for ANFH; however, approximately 31.5% of patients required conversion to THA within approximately 7 years. The authors emphasized the need for further randomized studies to identify the patients most suitable for this procedure and to determine which type of osteotomy provides the best outcomes (Quaranta, Miranda, Oliva, Aletto & Maffulli, 2021). Based on the available studies, the indications for this procedure are considered to include patients with minimal degenerative changes, preserved joint space, and no involvement of the acetabulum (Sen, 2009).

Nonvascularized Bone Graft

The method involves removing the necrotic area and filling the resulting defect with a bone graft in order to promote healing within the affected area (Banerjee et al., 2013). In a retrospective study involving 33 patients diagnosed with femoral head osteonecrosis, the effectiveness of non-vascularized bone grafting with the use of OP-1 was evaluated. During a 36-month follow-up period, 80% of patients with small- and medium-sized lesions did not require further surgery, while 82% of patients with Ficat stage II disease did not require reoperation. The results of the study showed that this method may delay the need for hip arthroplasty (Seyler, Marker, Ulrich, Fatscher & Mont, 2008). The outcomes of autologous tibial cortical bone grafting were compared with those of an allogeneic fibular graft in a long-term retrospective study involving 80 hips in 65 patients diagnosed with ANFH. The study concluded that the 5-year clinical survival rate was 59% and that autologous tibial bone grafting was more effective. Based on these findings, this method may be used as a joint-preserving technique, with its key components being decompression, removal of necrotic tissue, and filling of the resulting defect with bone grafts (Keizer, Kock, Dijkstra, Taminiau & Nelissen, 2006).

Vascularized Bone Graft

A study involving 470 patients with a 5-year follow-up period demonstrated an improvement in the Harris Hip Score, from 65 to 86.9, while radiological improvement was observed in 33.7% of patients. Despite these promising results, progression of osteonecrosis occurred in 9% of patients, whereas no radiological changes were observed in 57.3% of patients. However, its use is limited due to the long operative time, prolonged rehabilitation, and the risk of fracture of the proximal femur (Tang et al., 1998; Aluisio & Urbaniak, 1998; Vail & Urbaniak, 1996). A systematic review and meta-analysis evaluating the use of vascularized fibular grafting (VFG) assessed the failure rate, Harris Hip Score, and complications. The procedure demonstrated better clinical outcomes than other treatment methods and was associated with a lower rate of conversion to THA. The greatest benefits were observed in patients with Steinberg stage I–III disease, in whom the procedure delayed or prevented the need for hip arthroplasty. However, this treatment was also associated with a higher incidence of complications (Fang et al., 2013).

Total Hip Arthroplasty

Currently, total hip arthroplasty (THA) is most commonly performed in patients with advanced-stage avascular necrosis of the femoral head, particularly in cases where collapse of the femoral head has occurred (McGrory et al., 2007). Historically, THA was associated with poor outcomes in the treatment of femoral head osteonecrosis (Seyler, Cui, Mihalko, Mont & Saleh, 2007). However, following the introduction of press-fit implants, the outcomes of THA have become satisfactory, with improvements in patients' functional status (Pierce, Elmallah, Jauregui, Verna & Mont, 2015). In a study involving 98 participants (113 hips in total), including 50 patients who underwent bilateral THA, with a cementless stem used in one hip and a cemented stem in the contralateral hip, and 48 patients who underwent unilateral THA with a cementless stem, radiographic outcomes, polyethylene wear, clinical outcomes, implant loosening, and osteolysis were assessed over a mean follow-up period of 9.3 years. The results demonstrated that both surgical techniques provided comparable and satisfactory outcomes (Kim, Oh, Kim & Koo, 2003). Implant survivorship has also been compared between patients treated exclusively with THA and those who underwent hip-preserving procedures. A study including 192 patients, with a mean follow-up period of 75 months, evaluated both clinical and radiographic outcomes. No significant differences in implant survivorship were observed between the two groups, as patients who had previously undergone hip-preserving procedures did not demonstrate inferior outcomes following subsequent THA (Issa et al., 2014). With regard to restoration of hip function and improvement in clinical status, the majority of patients with avascular necrosis of the femoral head (ANFH) achieve good outcomes following total hip arthroplasty (Konarski et al., 2022).

3. Conclusions:

Treatment of avascular necrosis of the femoral head depends mainly on the stage of the disease and the patient's clinical condition. Pharmacological treatment may be beneficial in selected patients with early-stage disease, although its effectiveness has not been clearly established. Hip-preserving procedures, particularly core decompression and bone grafting, may slow disease progression and postpone total hip arthroplasty when performed before femoral head collapse. Osteotomy and vascularized bone grafting may also provide satisfactory results in selected cases, but their use is limited by technical difficulties and the risk of complications. In advanced disease with femoral head collapse, total hip arthroplasty remains the preferred treatment, providing good pain relief and improvement in hip function and quality of life. Further clinical studies are needed to determine the most effective treatment strategies for individual disease stages.

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