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Review Article

# Physical therapy intervention in early-stage femoral head osteonecrosis

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**Abstract**

Osteonecrosis of the femoral head is a progressively destructive disease of multifactorial origin. The etiology and pathogenesis of osteonecrosis of the femoral head are not yet clear. Management alternatives for the treatment of osteonecrosis of the femoral head consist of non-operative and operative treatment. The efficacy of non-operative treatment alone is the subject of heated debate in the literature. The purpose of this article is to review, update and summarize the non-operative treatment, particularly physical therapy modalities in patients with avascular necrosis of the femoral head in early stages. According to current literature these methods mainly include restriction techniques, electromagnetic stimulation, shockwave, immobilization-traction and rehabilitation training. Despite the evidence that these modalities when applied alone improve motor-function, pain relief and delay disease progression mainly through angiogenesis, osteogenesis and tissue regeneration, there is need for more research to elucidate their role and duration in early stages of avascular necrosis of the femoral head.

**Keywords:** Femoral head, Non-operative treatment, Physical therapy, Osteonecrosis

## Introduction

Osteonecrosis of the femoral head (ONFH) is a debilitating disease with a multifactorial pathogenesis that ultimately leads to hip joint destruction. In the international scientific literature ONFH is also referred as avascular (AVNFH) or aseptic (ANFH) necrosis of the femoral head[1]. The main feature of the disease is the reduction of vascular circulation, which results in the gradual destruction to the subchondral bone and then of the articular surface of the femoral head[2]. On a yearly basis 20.000-30.000 of new incidents of ONFH are diagnosed[3].The majority of patients are men between 35 and 45 years of age and their quality of life and career are increasingly compromised. It is therefore of major interest for the health systems as well[4].The target of ONFH treatment aims to the prevention of further deterioration of the joint. Patients, who remain untreated, will experience severe pain and movement limitation during the development of the disease. The main therapeutic interventions of ONFH are distinguished in operative (surgical) and non-operative (conservative) treatment[1,5]. Surgical methods include: core decompression (CD), osteotomy, bone transplantation and joint replacement. Conservative methods include: medication, weight bearing restriction and physical therapy[6,8]. The main goals of non-operative treatment are relief of symptoms, prevention of disease progression and improvement of functionality[7,8]. This type of treatment can be selected under specific circumstances such as early stages and small lesions of ONFH or among patients for whom surgical management is contraindicated. However, the outcome depends on the stage, volume, classification of necrosis as well as the age of the patient and the etiology of the disease[1,5]. This paper will review the current literature evidence of non-invasive methods in the early stages of ONFH with special focus on the effects of physiotherapeutic interventions.

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## Classification of Osteonecrosis of the Femoral Head

Following the last years, a number of different classification criteria have been suggested and described for the correct differentiation of stages and extent of damage of femoral head necrosis. These criteria have formed systems that provide useful information for prognosis and treatment decision. However, lack of a globally accepted classification system makes it difficult to compare and analyze data from different centers leading to a dispute over the staging of avascular necrosis of the femoral head[9,10]. A systematic review (Mont et al 2006) has revealed 16 classification systems for ONFH[11]. Among these, **Ficat** and **Arlet** (first classification system), **Steinberg** and **ARCO** classification systems are the ones most widely used in both previous and recent research, although there are differences between their diagnostic data[11-13].

### *Ficat and Arlet Classification*

- **Stage I**: Normal radiographic findings. Patients are asymptomatic.
- **Stage II**: Diffuse sclerotic and cystic lesions. Patients refer mild pain in the groin.
- **Stage III**: Crescent sign; Subchondral fracture. Patients report increasing pain and crepitus when moving the hip joint.
- **Stage IV**: Acetabular degeneration - Osteoarthritis - Femoral head collapse - Joint destruction. Patients have pain with activity[9,10,13,14].

### *Steinberg Classification (modification of Ficat and Arlet classification)*

- **Stage O**: Normal or non-diagnostic radiograph, bone scan and MRI. No clinical symptoms.
- **Stage I**: Normal radiograph; abnormal MRI and/or bone scan. Osteonecrosis findings. Referred pain in the groin.
- **Stage II**: Radiographs show abnormalities consistent with avascular necrosis; abnormal MRI and/or bone scan. Mixed findings include osteopenia and/or sclerosis and/or subchondral cysts, without any subchondral lucency. Lucent and sclerotic changes in femoral head.
- **Stage III**: Crescent sign; plain radiograph indicate subchondral collapse without flattening. Abnormal MRI and/or bone scan.
- **Stage IV**: Crescent sign; radiograph indicate flattening of femoral head. Abnormal MRI and/or bone scan. Surface collapse and dome depression.
- **Stage V**: Clear radiographic evidence of joint narrowing and/or acetabular changes; abnormal MRI and/or bone scan. Progressive degenerative changes of femoral head will occur.
- **Stage VI:** Radiographs present advanced degenerative changes in both the femoral head and acetabular surface; abnormal MRI and/or bone scan[10,15-17].

### *Association Research Circulation Osseous (ARCO) international classification*

- **Stage O**: All findings present normal or non-diagnostic. Diagnosis is made by histology only. Techniques: X-ray, CT, Scintigraph, MRI.
- **Stage I**: Normal findings on X-ray and CT; abnormal on Scintigraph, and / or MRI. MRI scans detect a band lesion of low signal intensity around the necrotic area. Techniques: Scintigraph, MRI, quantitate on MRI.
- **Stage II**: No crescent sign; X-ray: subtle signs of sclerosis, osteolysis and focal porosis can be identified in the femoral head. Techniques: X-ray, CT, Scintigraph, MRI, quantitate on MRI and X-ray. There is no evidence of subchondral fracture.
- **Stage III (Early)**: Crescent sign; on the X-ray and/or flattening of articular surface of femoral head (no collapse). Techniques: X-ray, CT and quantitate on X-ray.
- **Stage III (Late)**: Collapse; On the X-ray and/or flattening of articular surface of femoral head. Techniques: X-ray, CT and quantitate on X-ray. Surface collapse and dome depression.
- **Stage IV:** Osteoarthritis sign: joint space narrowing, acetabular changes and joint destruction. Techniques: X-ray only[1,10,12,13].

## Physical therapy management (Non-operative treatment)

### *Weight bearing restriction*

For patients in the early (Arco stage: 0–I) or middle stages (Arco stage: II–III), weight bearing with crutches or other gait aids is recommended to regain function and relieve painful symptoms[18]. Physical therapists should instruct the patient how to correctly use these devices[19]. Although no-weight-bearing therapy has been used in the early stages of the disease, a recent study shows that weight bearing restriction when combined with pharmacological agents or surgery and not as stand – alone therapy can be an evaluative therapeutic option in preventing the progression of ONFH[20].

### *Biophysical therapy*

- Pulsed electromagnetic fields (PEMFs)

Electromagnetic therapy constitutes an easy and safe way of treatment aiming to heal numerous health problems. Pulsed electromagnetic fields (PEMFs) are produced and transmitted by special devices to the human body[21]. According to current literature PEMFs appear to play an important role in angiogenesis and osteogenesis[22].

In a review by Raymond and Carlo published in 2015 regarding the effects of conservative treatment on hip osteonecrosis, a retrospective analysis of 66 consecutive patients who received PEMFs for the treatment of avascular necrosis (Ficat stage I-II-III) was presented. All participants received PEFMs 8 hours per day for 5 months with intermediate follow-up about 2 years. The results showed

that 6% of Ficat stage I-II AVN and 80% of Ficat stage III AVN required surgery at final follow-up[20].

Furthermore, Seber et al (2003) conducted a study of 2 cases with Ficat- Arlet grade 2 osteonecrosis of the femoral head who had received PEMFs for 6 months as sole treatment with duration of 10 hours daily and 5-12- years' follow-up. They concluded that PEMFs stimulation alone may be an alternative therapy in the early stages (Ficat -Arlet grade I and II) of disease for patients that cannot be operated[23].

Similar findings have been reported by older studies that have demonstrated the effectiveness of applying magnetic fields in the early stages of ONFH[3]. Although the number of studies regarding PEMFs on ONFH that have been published are quite limited, this modality seems to be a promising tool in stabilizing and delaying the time until joint replacement becomes necessary.

• Extracorporeal shockwave therapy (ESWT)

Extracorporeal shock waves are a non-invasive method based on acoustic waves of extremely high pressure and velocity. Shock waves travel through fluid - soft tissue and cause a change of impedance between soft tissue and bone interface which results in energy deposition[24]. It seems that, this deposition might be responsible for the osteogenesis' and angiogenesis' effects of this therapy. Although the effects of ESWT on ONFH have been investigated by a number of studies, the mechanisms and effectiveness of this modality are not clear yet.

In a recent research article by Xie et al (2018) indicated the long-term outcomes of ESWT for early-stage nontraumatic ONFH. Forty-four hips (31 patients) were included in the study, which were categorized according to the Arco scale (I, II & III). The mean follow-up in the current retrospective study was more than 10 years after treatment with significant improvements, such as pain relief and functional restoration. Especially, better results were seen in patients with Arco scale: I&II. Some patients (1 hip-Arco scale II and 4 hips-Arco scale III) were treated with total hip arthroplasty during follow-up[25].

A meta-analysis of 17 studies published in 2017 investigated the therapeutic effects of ESWT on ONFH. Eleven of these studies examined the sole effects of ESWT on ONFH. Four studies compared the effects of ESWT with surgical procedures and two studies compared ESWT with non-invasive modalities (alendronate, HBO).Authors concluded that extracorporeal shockwave appears to be a safe and effective method to improve the motor function and pain relief in patients with ONFH (Arco scale: 0-III), especially those at early stage (Arco scale: 0-I)[26].

In another study published by Yong Han et al (2016) 19 patients (30 hips) with ONFH were randomly divided into two groups which were allocated to receive 4 weekly sessions of ESWT, at different energy levels. The aim of the report was to evaluate the effectiveness of lower energy density ESWT, which is a more practical and realistic treatment option at the clinical level, than the methods previously discussed. It was demonstrated that in both groups there was improvement in pain and function ''up to 6-month follow-up''. Despite the limitations in methodology of this study, ESWT at low-EFD seemed to be beneficial in patients with early stage of ONFH[27,28].

On the other hand, a study by Wang Ching-Jen et al (2016) emphasized the impact of different ultrasound dosages on early ONFH. Thirty three patients (42 hips) were randomized into three groups (Group A: 2000/ B: 4000/ C: 6000 impulses of ESWT). According to their findings, only high doses of ESWT may have beneficial systemic effects such as angiogenesis, anti-inflammation, tissue regeneration and pain threshold. Ultimately, ESWT can lead to prevention of femoral head collapse by enhancing microcirculation of peri-necrotic areas[29].

More than 600 cases of patients in early stages (I & II) of osteonecrosis of the femoral head have been studied by the Neapolitan school with appreciable results. They, also, demonstrated that ESWT seemed to be an effective non-invasive treatment with greater effects during initial stages of disease[30].

According to a review published by Wang Ching-Jen et al in 2015, it appears that ESWT can be characterized as a new therapeutic tool with the ability to replace and minimize surgical interventions (mainly at Arco stage I&II) in patients with ONFH, as well as their risks[31].

In a single case reported by Levent et al (2014) a 57-year-old woman with lumbar and left hip pain had been diagnosed with avascular necrosis of bilateral femoral heads (stage I). After the utilization of ESWT, a significant reduction in pain and functional recovery was observed[32].

Additionally, a two-year prospective clinical study with 36 patients examined the long term effects of ESWT on early ONFH according to the ARCO scale. Results indicated that ESWT may contribute positively to the reduction of pain and slowing down the progression of the disease[33]. Also, Lee et al (2015) have reported similar results, in a study that investigated the effects of ESWT on early ONFH classified by ARCO scale[34].

Moreover, ESWT seems to be more beneficial than core decompression on early-stages of ONFH with long term follow-up[35,36]. Nevertheless, there is no evidence showing that a combination with other conservative methods could improve the curative effects of ESWT[37-39]. Additionally, ESWT has also showed promising results in treating patients with ONFH and various risk factors such SLE, SARS and leukemia[40-43]. Based on current literature evidence, the above results should be interpreted carefully due to methodological limitations of the studies reviewed and further research is requisite to validate the effect of ESWT on ONFH[44].

## Immobilization and Traction

Regarding immobilization and traction, the evidence is tremendously limited. According to literature the above techniques can be applied both in initial and intermediate

stages of development of ONFH[1]. It is skeletal traction: timing, frequency, duration and the intensity of treatment are determined by the specialist physical therapist.

## Rehabilitation Training

Physical therapy focuses on exercises that enhance joint mobility and strengthen the muscles around the affected joint[19]. Movements that may apply excessive forces to the hip joint can be dangerous and should be avoided. Rehabilitation training plays an important role to maintain and increase joint mobility, promote muscle strengthening, restore function and prevent muscle disuse atrophy[1]. Such a program would include both passive and active exercises as well as stretching. Passive exercises are passive movements of the hip aiming to joint mobility. Active exercises are energetic movements of the hip applied at all dimensional motions of the joint. They aim to trigger muscle activity and can be performed in lying, sitting or standing position[19]. Muscle activation should be considered as the main goal of a rehabilitation program rather than being an adjuvant treatment. Training should focus on active muscle activity. However, time and intensity of exercising need to be progressively increased according to ONFH stage, treatment, hip rating scale and gait analysis results[1]. The new guidelines published recently (2017) by the Chinese Orthopedic Association for the treatment of ONFH want rehabilitation exercises to evolve as following:

- **Hip flexion lying supine with hip and knee flexed at 90°**
- **Hip abduction from sitting position with knees full extended**
- **Hip flexion from standing position with hip and knee flexed at 90°**
- **Squat with the help of a fixture**
- **Adduction and abduction – circular movement of the affected hip while standing with a help of a fixture**
- **Walking with crutches or cycling training[1]**

The aforementioned exercises focus on hip and thigh muscles but also engage core muscles as they play a supporting role. Endurance training and coordination training is important in order to improve functionality at a later, more advanced, stage of rehabilitation exercise program. Cycling or walking can promote endurance as mentioned above. Additionally, coordination can be improved with complex balancing exercises during physical therapy sessions[1]. Lastly, it is worth mentioning that physiotherapeutic intervention appears to contribute positively both pre-operatively (early stages) and post-operatively in patients with ONFH. In a prospective multicenter study, 46 patients with sickle cell disease in the early stages of ONFH were randomized in two groups. The first group with 17 patients underwent operative treatment (core decompression) and then followed physical therapy program (stretching and strengthening of hip muscles). The second group with 21 patients, treatment was solely based on physiotherapy program. The authors concluded that there was no difference between the two groups which highlighted the value of the physiotherapy rehabilitation program. Thus, the joint function was improved and further surgical intervention was postponed by an average of 3 years after therapy[45].

## Conclusion

Femoral head Osteonecrosis remains a significant source of patient morbidity, leading to pain and hip dysfunction. The present review demonstrated the feasibility and safety of an intensive multiplex physical therapy management program with patients in the early stages of ONFH. Physiotherapy methods as mentioned in this paper, according to research data, are not able to reverse hip osteonecrosis but they can reduce the progression of disease and decrease pain. The most successful outcomes have been demonstrated in patients whose disease are diagnosed and treated early (Arco stage I and II) but surgical procedure is vital at final stages (Arco stage III and IV). Non-operative modalities: weight bearing restriction, PEMFs, ESWT, immobilization-traction of the joint and rehabilitation training program are effective physical modalities which have yielded important findings in the treatment of ONFH. Nonetheless, better designed studies with long-term results are required before definitive conclusions can be drawn regarding the role of physical therapy in early stages of osteonecrosis of the femoral head.

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