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THE EFFICACY OF USING SVF AND BMAC TO TREAT POST-COVID AVASCULAR NECROSIS OF THE FEMORAL HEAD

S.U. Asilova [1], A.B. Mirzaev [2], M. Salomov[3]

1 DSc, Professor, Department of Traumatology and Orthopedic, Tashkent Medical Academy, Tashkent, Uzbekistan
E-mail: asilova_saodat@mail.ru

2 Bachelor's degree student, School of Medicine, Central Asian University, Tashkent, Uzbekistan
E-mail: akbar.orthopedic@gmail.com

3 MD., Department of Traumatology and Orthopedic, Tashkent Medical Academy, Tashkent, Uzbekistan
E-mail: m.salomov022@gmail.com

ABSTRACT

Avascular necrosis of the femoral head (ANFH) is a complex condition recently associated with the coronavirus pandemic. It predominantly affects working-age men, increasing the risk of early joint failure and subsequent revision after total hip replacement. A crucial aim in modern orthopedics is to delay end-stage necrosis to avoid early joint replacement surgeries.

This study, conducted at the Akfa Medline clinic, presents outcomes from employing cell therapy decompression in 36 post-coronavirus infection ANFH patients. Study criteria included patients in ARCO stages 1 and 2, aged 18 to 65 years, excluding cases from post-traumatic avascular necrosis, alcohol-related avascular necrosis, or those associated with rheumatoid diseases and steroid use. Procedures involved cellular material collection, femoral head decompression, and cellular material introduction into the necrotic area.

Clinical data analysis, including the Harris Hip Score (HHS) and Visual Analog Scale (VAS), demonstrated significant patient improvement. MRI studies confirmed structural hip joint changes, reduced swelling, and synovitis regression.

The study concludes that femoral head decompression combined with cell transplantation like PRP, BMAC, and SVF is a safe and effective treatment for early-stage avascular necrosis of the femoral head. This technique has successfully reduced femoral head collapse rates and may delay or prevent the need for total hip arthroplasty.

Key words: covid-19, avascular necrosis, core decompression, BMAC, SVF, PRP.

INTRODUCTION

Aseptic necrosis of the femoral head (ANFH) is a common multifactorial condition. Known contributing factors to its development include steroid use, alcohol consumption, systemic lupus erythematosus, radiation exposure, cytotoxic drugs, hyperlipidemia, pancreatitis, gout, among others. [8] It should be noted that the frequency of this disease has increased sharply during the post-coronavirus pandemic. As described in the literature, the pathogenesis of non-traumatic osteonecrosis is multifactorial. It involves a combination of various mechanisms, such as hypercoagulability, suppression of angiogenesis, hyperadipogenesis, altered bone remodeling, and genetic predisposition. [9] The epidemic of avascular necrosis of the femoral head in the country after the pandemic can be explained by coagulopathy, endothelial dysfunction caused by the virus itself, and steroids used to stop the cytokine storm during the disease. Therefore, macro- and microvascular changes and tissue damage caused by SARSCoV-2 infection increase the risk of developing osteonecrosis after COVID-19. [12]. Steroid-induced ANFH constitutes approximately 10-30% of all non-traumatic aseptic necrosis cases. The incidence of steroid-induced avascular necrosis is around 10,000–20,000 cases annually in the United States, accounting for about 10% of all hip replacements. [1]

Because this condition is more prevalent among working-age men, there's a higher risk of early implant failure and subsequent revision surgeries after total hip replacement. This poses a challenge for orthopedic specialists treating younger patients with hip joint issues. Therefore, a key goal in modern orthopedics is delaying the advanced stages of necrosis to prevent premature joint replacement. Various medical and surgical interventions outlined in medical literature aim to slow down the disease progression. [13]. All types of conservative and early surgical treatment are aimed at improving blood supply in the avascular area of the femoral head. [3] The technique proposed by Ficat and Arlet aims to reduce the increased intraosseous pressure in the femoral head; therefore, they called this procedure "core decompression of the femoral head." [2]. Further, with the development of orthobiology, methods related to "cell therapy" began to be used. In modern scientific research, there is increasing evidence indicating that the use of bone marrow concentrate (BMAC) during decompression leads to an increase in local bone activity in the area of necrosis of the femoral head [6]. Thus, this publication presented the results of using BMAC, stromal vascular fraction (SVF), and platelet-rich plasma (PRP) after preliminary decompression of the necrosis focus in 30 patients with ANFH.

Materials and methods. At the Akfa Medline clinic, decompression was performed using cell therapy in 36 patients with a total of 52 hip joints. The inclusion criteria included patients with aseptic necrosis of the femoral head after a coronavirus infection at ARCO stages 1 and 2, aged 18 to 65 years. Exclusive criteria were the presence of post-traumatic avascular necrosis of the femoral head caused by alcohol factors, as well as the presence of rheumatoid diseases with periodic use of steroids. Among the 52 hips, 45 (86.5%) were in ARCO stage 2, while 7 (13.5%) were in ARCO stage 3a. Among the patients who underwent procedures, 30 (83.3%) were male, while 6 (16.7%) were female.

The key elements of operation encompass:

1. Collection of cellular material;
2. Decompression of the femoral head;
3. Introduction of cellular material into the focus of necrosis.

Operation. We first collect venous blood from the patient in a volume of no more than 15 ml into an "ARTHREX ACP" syringe to obtain autologous condensed plasma (ACP), which has pronounced therapeutic properties. We seal the injection area with alcohol-aseptic dressings. We separate platelets by centrifuging a tube with venous blood at 1500 rpm for 5 minutes in a Rotofix apparatus. As a result of the treatment, 5 ml of autologous condensed plasma (ACP) is obtained.

When taking adipose tissue into the subcutaneous fat under local anesthesia, 2.0 ml of 0.5% novocaine is administered through an infusion cannula, and we infiltrate the tissue. Thirty minutes after administering the specified solution, we collect about 30 ml of adipose tissue using a special cannula. We seal the site of adipose tissue collection with alcohol-aseptic dressings. By double centrifugation for 4 minutes at a speed of 2400 rpm and filtration in two specialized ARTHREX ACP syringes, we obtain about 6 ml of stromal vascular fraction (SVF).

Next, we collected red bone marrow from the iliac crest in 30 ml using a Jamshidi needle in a 50 ml syringe with 0.6 ml of heparin. Using an adapter, the resulting red bone marrow is transferred into ARTHREX ACP syringes and processed by centrifugation for 20 minutes at 3200 rpm. During centrifugation, the bone marrow is separated into three parts: plasma, bone marrow mononuclear cells, and red blood cells. The upper part, plasma, and the lower part, red blood cells, are removed. Next, the middle portion - bone marrow mononuclear cells - is centrifuged again for 10 minutes at 1000 rpm. It is divided into the lower erythrocytes and the upper red bone marrow concentrate (BMAC). Ready-made red bone marrow concentrate (BMAC) - the upper cellular portion in a volume of 3

ml - is mixed with 6 ml of stromal vascular fraction (SVF) and 5 ml of autologous condensed plasma (ACP).

The patient is placed supine with internal rotation of the lower limb on the operating table. Under spinal anesthesia, after three times treatment of the lower limb with a solution of 2% iodine, in the projection of the greater trochanter along the outer-lateral projection of the thigh, we make a longitudinal incision up to 2 cm long, exposing the subtrochanteric region layer by layer 2 cm below the upper edge of the greater trochanter. Under C-arm control, a pin is passed through the subtrochanteric region to the necrotic area. Using an extra-articular drill, we form a bone canal in the intertrochanteric region, neck, and head of the femur, first 4.5 mm in diameter in different directions, then 8 mm long in the middle of the necrotic area, for decompression of the femoral head. Using a surgical spoon, we completely remove the necrotic area. The bone canal and the site of the removed area of necrosis are drained with a saline solution through the system tube. Through the tunnel, using a special trocar, we introduce into the necrosis zone a ready-made mixture of SVF, ACP and BMAC with a total amount of 14 ml. We close the wound layer by layer.

Results. The average follow-up period was 24 months. Analysis of clinical data showed that the average HHS (Harris Hip Score) before surgery was 61 points; on the fifth day after surgery - 76 points; after 1.5 months - 88 points; and after six months - 86 points. The HHS average remained at 86 points throughout the year but varied from 97 to 60 points. After two years, the average score was 87 points. In 26 cases (72%), excellent results were noted on the Harris scale; in 4 cases (11%) - good; in 5 cases (14 %) - satisfactory; and in 1 cases (3%) - unsatisfactory due to progression of femoral head collapse. (Diagram 1) In addition, the results were assessed using the VAS scale. Before surgery, patients had an average VAS score of 5.5. On the fifth day after surgery, a decrease in pain syndrome to 1 point was noted, which may be explained by a decrease in intraosseous pressure in the femoral head. After six months, the average VAS score was 1.5; after two years, it was less than 2 points. (diagram 2) In 3 patients, total hip replacement was performed.

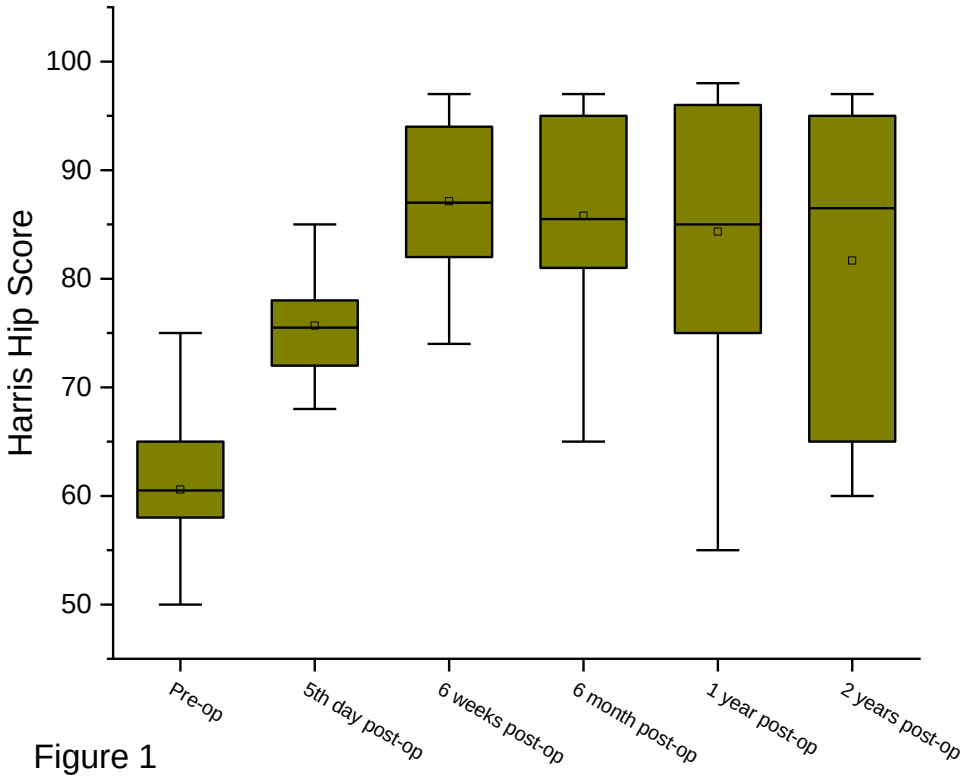


Figure 1

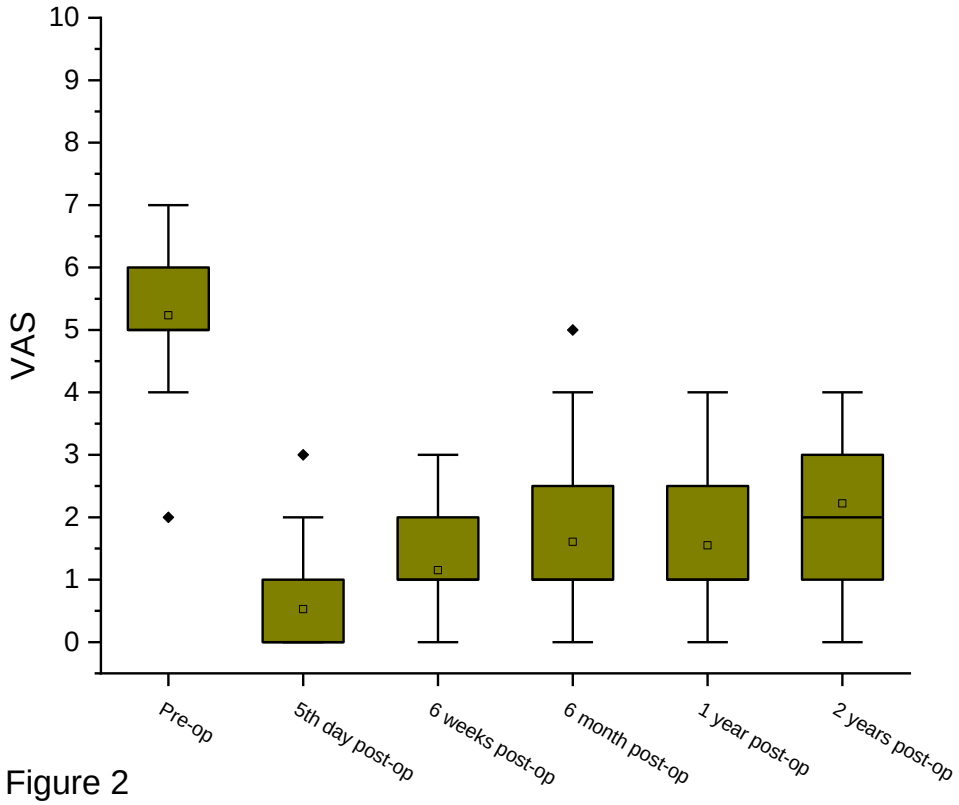
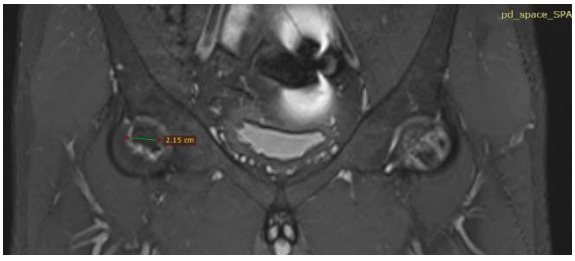
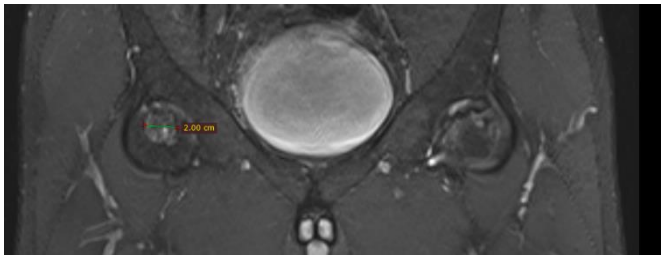


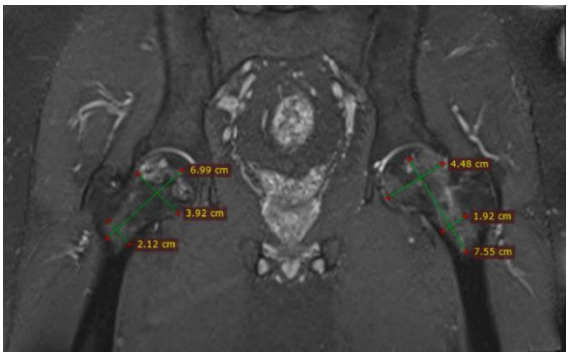
Figure 2

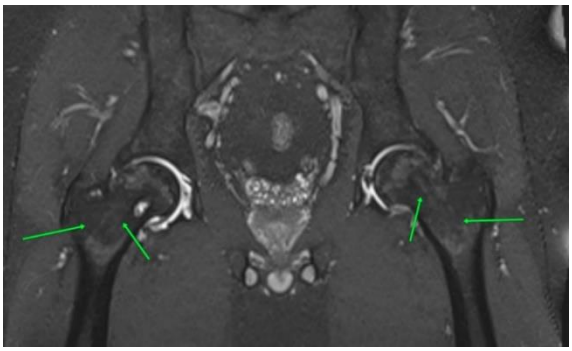
A comparative assessment of the structures of the hip joints with using MRI before and after organ-saving surgery. When studying dynamic MRI data, we assessed the severity of bone marrow edema of bone marrow edema of the proximal femur (Fig. 1a, 1b), the integrity of the subchondral bone plate, and the length of the demarcation zone (Fig. 2a, 2b). Bone marrow edema, best seen on STIR images, was associated with clinical presentation and pain severity. In 28 cases (77 %), where widespread edema covered the entire head and neck of the





femur, according to MRI, the pain syndrome reached its highest intensity. After surgery, patients noted a decrease in pain by the fifth day after the procedure. In 15 cases (42%), a decrease in bone marrow edema in the femoral head was observed 6-12 months after decompression, while in 8 patients (22 %) the edema remained at the same level. There was no increase in the area of edema. All patients with positive clinical dynamics and MRI changes showed regression of synovitis of the





hip joint. Also, in 7 (19.4 %) patients, progression of femoral head collapse was observed, and 3 (8.3 %) patients underwent total arthroplasty due to increased pain.

Discussion. The literature discusses different techniques for decompressing the femoral head, initially developed by Ficat and Arlet. [2]. Since the pathogenesis of osteonecrosis was assumed to be associated with increased intraosseous pressure causing intravascular compression of the vessels of the femoral head, this procedure was considered effective. Thus, it has been hypothesized that early treatment using a decompression technique will reduce the intraosseous pressure in the femoral head, thereby restoring normal vascular blood flow [10]. This technique has shown reasonably satisfactory results in preventing femoral head collapse in the early stages. However, there may be some

disadvantages, such as intraoperative cartilage damage and the risk of postoperative subtrochanteric femoral fracture. [4] The technique's effectiveness directly correlates with the stage of the disease for which the intervention was performed. The effectiveness at the first stage exceeds 95%; at the second, more than 77%; then, at stage 3 of the disease, it drops to 52% with a high risk of collapse. [7] In the first stage of the disease, patients rarely turn to orthopedists; therefore, many patients turn to the second stage of the disease. Many authors have tried to increase the effectiveness of decompression using cell therapy. For example, Gangji et al. [5] conducted a prospective study on 19 patients (24 hips) with early-stage femoral head necrosis. In the control group, only decompression of the femoral head was performed; in the main group, decompression was performed in combination with the implantation of bone marrow cells. They concluded that transplanting bone marrow cells into the area of osteonecrosis may be an effective treatment for the early stages of the condition. However, the study did not describe the bone marrow concentration technique, stem cell manipulation, or route of administration. Another study from Korea described the use of autologous adipose-derived MSCs supplemented with PRP and hyaluronic acid administered percutaneously in two patients with osteonecrosis of the femoral head [11]. The results of magnetic resonance imaging showed some improvement in osteonecrosis. However, these are only practical cases, and the data are not statistically significant. In a randomized clinical trial conducted by the research group led by Tabatabaee et al., a cohort of 28 hips previously classified as ARCO stage I, II, or III were analyzed. In the study, 18 patients underwent decompression of the femoral heads exclusively, while the remaining patients were supplemented with bone marrow concentrate during a two-year follow-up period. The study results lead to the conclusion that the use of concentrated autologous bone marrow-containing mesenchymal stem cells, combined with decompression, is effective in the early stages of osteonecrosis of the femoral head. However, it should be noted that the main limitation of this study is the limited size of the patient cohort studied. [14] In our practice, we utilized mesenchymal cells from bone marrow, adipose tissue, and platelet-rich plasma to enhance the effectiveness of femoral head decompression. However, we did not conduct a comparative analysis between the study group and the control group. Nonetheless, there was a notable improvement in hip function as per the Harris scale and a reduction in pain based on the VAS scale. Additionally, only 10% of patients underwent total hip replacement. It's worth noting that orthopedic surgery is entering a new phase where biological treatment methods are beginning to complement and, in some cases, replace the mechanical approaches used in the past. [15]

Conclusion. Combining femoral head decompression with autologous PRP, BMAC, and SVF transplantation is a safe and effective treatment for early-stage osteonecrosis, effectively reducing the incidence of femoral head collapse and delaying or, in some cases, preventing the need for total hip arthroplasty.

Author contributions. Akbar Mirzayev and Mubosher Salomov were the initiators of the proposed concept and made significant contributions to the final manuscript. Saodat Asilova was responsible for the development of the theoretical framework and provided support in data collection.

Conflict of interest. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Declaration of interests: no declare

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