

Autologous Bone Marrow Cells with Core Decompression for Treating Avascular Necrosis of the Femoral Head

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Abstract: ***Background:** Avascular necrosis of the femoral head (AVN) is a progressive pathological process resulting from disruption of blood supply to the femoral head and elevation of intraosseous pressure. Early stage AVN can be managed by various techniques, the results have been disappointing, total hip arthroplasty is frequently the only durable option for pain relief and restoration of function. The newer treatment modalities include using high stem cell concentration in the vicinity of the necrosed tissue with core decompression to prevent disease progression. **Patients and methods:** A single armed study done from May to November 2023, the total number of patients was 6, (2 Female 4 male). total joints treated 10, Etiology include corticosteroids use, systemic lupus erythematosus mostly related to steroid use in covid 19 epidemic. The age of the patients ranges from 25 - 55 years. The procedure includes core decompression with autologous bone marrow derived mononuclear cell injection inside the femoral head using local anesthesia ultrasound and fluoroscopy guided without drilling. **Results:** The procedure was safe results showed improvement in the Harris hip score from 48.7 ± 6.6 to 88.00 ± 4.6 ($p < 0.001$) in all 6 patients. With radiological proof by x ray and magnetic resonance imaging in 3 cases according to The Mitchell's grade regressed from C to B in three patients. **Conclusions:** This single arm short term study showed that core decompression with autologous bone marrow derived cell therapy under local anesthesia with ultrasound and fluoroscopy guidance is safe simple and effective new method and it is a form of minimal manipulative treatment and merits such treatment in larger and longer-term study.*

Keywords: avascular necrosis of the head of femur, bone marrow derived cells, cell therapy, hip

1. Introduction

Avascular necrosis of the femoral head (AVN) is a progressive pathological process resulting from disruption of blood supply to the femoral head and elevation of intraosseous pressure.

The pathophysiology of avascular necrosis (AVN) is unclear in spite of attempts to provide a proper model. However, there are several recognized conditions and environmental insults that can predispose patients to AVN. Traumatic causes include fracture head or neck of the femur, nontraumatic causes include sickle cell anemia, endocrine conditions like Cushing syndrome, auto immune disease like systemic lupus erythematosus, use of corticosteroids, alcoholism, organ transplantation and others.

Although these factors may increase a patient's risk for developing AVN, others propose that the disease results from a clotting disorder or genetic abnormality that leads to vascular compromise.

In idiopathic cases the underlying abnormality may be a coagulation factor gene defect.

Symptoms can vary widely, depending on the stage at presentation, In the earlier stages of AVN, patients may note an insidious onset of pain, without a clear cause or inciting event, and will often have a normal range of motion; however, this can be limited by pain, especially with internal rotation of the hip. With progression of the disease, this

insidious groin discomfort may be followed by a sudden onset of severe pain, Late - stage disease is marked by mechanical difficulties with reduced motion and painful movements.

The diagnosis of AVN is usually done by clinical and radiological signs; early stage disease needs better resolution like in MRI (magnetic resonance imaging) or computed tomography.

Late - stage disease can be seen by plain X - ray. Radiological features are important in staging the disease for proper treatment [1].

Usually AVN affects patients aged 20 - 40 years with the average presenting age is 38 years. [2]

Early stage AVN can be managed by various techniques, (core decompression, osteotomy, and medical treatments), the results have been disappointing, with up to 40% of patients progressing to total hip arthroplasty, however advanced stages 3 or more according to Steinberg classification [3] total hip arthroplasty is frequently the only durable option for pain relief and restoration of function [4].

The newer treatment modalities include using high stem cell concentration in the vicinity of the necrosed tissue with core decompression to prevent disease progression [5].

2. Patients and Methods

Patient's characteristics:

Volume 13 Issue 11, November 2024

Fully Refereed | Open Access | Double Blind Peer Reviewed Journal

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A single armed study done from May to November 2023, the total number of patients was 6, while the number of femur head was 10. Female patients were 2 and male patients 4.

Etiology was mainly corticosteroids, The age of the patients range from 25 - 55 years.

The stage of the disease was advanced according to Steinberg score (table 1).

Bilateral femoral head involved in 4 cases.

Table 1: Steinberg classification for avascular necrosis of the femoral head.

Stage	0
No symptoms	Normal X - ray
MRI non diagnostic	
1	Mild pain in the affected hip Pain with internal rotation Normal X - ray MRI diagnostic
2	worsening or persistent pain Increased sclerosis or cysts in the femoral head
3	Subchondral collapse producing a crescent sign
4	Flattening of the femoral head
5	Normal joint space Joint space narrowing with/without femoral head involvement
6	Advanced degenerative changes

Steinberg classification for avascular hip necrosis begins from stage zero with normal joint without pain or radiological evidence of necrosis, to stage 6 with advanced degenerative changes.

Inclusion criteria:

- 1) Patients with both sexes.
- 2) Avascular hip necrosis irrespective Of stage.
- 3) Age from 25 - 55 years.

Exclusion criteria:

- 1) History of bleeding tendency.
- 2) History of malignant disease.
- 3) Critically ill patient.

Procedure:

Under local anesthesia and ultrasound guidance after getting patient consent, a 2 - 3 mm incision is made in the skin over the posterior iliac crest using a disposable bone marrow aspiration needle size according to body built with single site multiple aspiration to withdraw around 60 cc of bone marrow in ACD washed syringes and (1 to 8 acid citrate dextrose/bone marrow product) for anticoagulation. A sample of the product is sent for cell counting and trypan blue exclusion dye test for viability.

The whole product is concentrated using centrifuge and special bone marrow concentration kit (seawon meditech) 30 cc each kit centrifuge for 6 minutes followed by extraction of total 6 cc for 60 cc product which is sufficient for both hip joint.

Anterior approach was used under ultrasound guidance and local anesthesia to avoid neurovascular bundle. Decompression is done under fluoroscopic screen and 3 ml of bone marrow cells was injected to the site.

After the procedure all patients are discharged home and allowed to weight - bear as tolerated with crutches for 2 weeks.

The cellular count of the bone marrow concentrate injected was 8×10^7 per cubic ml.

End point:

- 1) Clinical and radiological improvement.
- 2) Clinical or radiological proof of disease progression.

3. Results

Table 2 showed the results of our study, clinical response was remarkable including reduction in pain and improvement in joint mobility very early after the procedure, and 6 months later, the Harris hip score showed improvement in all cases (100%).

The score improved from 48.7 ± 6.6 to 88.00 ± 4.6 ($p < 0.001$).

AS scores for Quality of Life Score for Chronic Hip Disease was assessed and found at 8.

The score is 10 in normal and 1 in severe limitation.

The radiological evaluation using MRI significantly correlated [figure 1]

As the lesion converted from Mitchell's grade C to grade B after the procedure by 6 months.

The HHS and the AS score for Quality of Life Score for Chronic Hip Disease.

4. Discussion

Percutaneous stem cells implantation and decompression has been shown to immediately restore the mechanical stability of affected bones, prevent further risk of bone fractures, and allow immediate weight bearing. It is emerging as one of the most promising procedures for patients with painful bones with osteonecrosis who are unsuitable for surgery or who show late stages of disease. This study aimed at describing the procedure, indications, and benefits of percutaneous implantation of stem cells for painful osteolytic changes percutaneous implantation and experienced effective pain relief and recovery of hip and knee function postoperatively. In addition, no perioperative complication was observed. Percutaneous implantation and decompression for osteolytic head and distal femur offers effective pain relief and restores impaired hip and knee function. Although this method may be a safe option, larger samples of retrospective or prospective confirmation are warranted.

We found this new technology including percutaneous bone

marrow derived mononuclear cell injection under local anesthesia and ultrasound with fluoroscopy showed decreased in the pain scale from 8 to 1 in all patients after the procedure in six patients.

Marked x ray and MRI Improvement was observed in 3 patients 6 month time after the procedure. The Mitchell's grade regressed from C to B in all patients.

This technique offers a chance for patients with advanced stages of avascular hip necrosis to have a new method to reduce pain and improve function and life quality with minimal surgery. Our results are promising though small number of cases,

A large review of 11 studies with 507 participants showed that core decompression with bone marrow cell injection was more effective than core decompression alone and increased Harris hip score [9].

Regarding pathophysiology it is known that there is an increase in the fatty tissue inside the intertrochanteric portion of the osteonecrotic hip with a significant reduction in stem cell pool [10].

One of the important facts in the clinical outcome of the bone marrow procedure for avascular hip necrosis is the concentration of the bone marrow cells near the necrotic area; we observed that in most procedures that were done they mentioned the use of 10 cc syringes with steady pressure aspirate [11].

We should point to the following facts that are very important to gain best cellular content:

- 1) High concentration of stem cells is usually yielded in the bone marrow concentrate as we got 1×10^7 in 1 cc of the product.
- 2) Single aspiration site with multiple levels with small size syringe 10 cc punctures is more convenient to the patient.

In our study we used a mean of 1×10^7 bone marrow cells in 1 cc and 90% viability obtained.

The data showed that the total number of MSCs present in 1 cm³ of a femoral head was on average of 700 ± 264 MSCs per cm³. Since the femoral head has an average volume of 50 cm³, a total of 35,000 MSCs may be considered as a useful approximation of the number of MSCs present in a femoral head [12].

It is a very important task to clarify the precise factors in the pathophysiology and healing process as there is a multitude of variables including type of cells (bone marrow or mesenchymal cells, osteoblasts or others) source (bone marrow, adipose, others) concentration, timing disease stage, and procedure that need to be discussed in future work [13].

5. Conclusions

This single arm short term study showed that core decompression with autologous bone marrow derived cell therapy is safe and effective method and it is a new form of

minimal manipulative treatment and merits such treatment in larger and longer term study.

Abbreviations

SCD=sickle cell disease, SLE=systemic lupus erythematosus, NS=non - significant.

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