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Hip Abductor Muscle Strength In Patients With Avascular Necrosis of the Femoral Head

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ABSTRACT

Background: Studies have reported that hip abductor muscle weakness is a common finding post-surgery in patients suffering from avascular necrosis of the femoral head. Hence, our main study aimed to estimate the hip abductor muscle strength in patients with avascular necrosis of the femoral head.

Methods: This was a prospective observational study. The patients were recruited per the inclusion criteria of being more than 18 years of age and having unilateral avascular necrosis of the femoral head. Any patient with revision surgery or any other surgery in the hip was excluded. These subjects recruited for the study of their hip AVN were graded as per Ficat and Arlet classification by an experienced radiologist and underwent surgery. Following this, the hip abductor muscle strength of both lower limbs was measured using a sphygmomanometer. Their hip abductor muscle strength was measured during admission, after the surgery on postoperative day 03, and at discharge. All the recruited patients were given physiotherapy exercises based on strength, range of motion, and ambulation training from admission.

Results: A total of 65 patients were recruited for the study. Fifty-four males and eleven females were part of the study. Independent t-test was used to find the differences between pre-surgery and post-surgery measurements. No statistically significant difference was observed in the hip abductor muscle strength from pre-surgery to post-surgery in the lower limbs. However, their mean values showed improvement in muscle strength from 97.43mmHg (pre-surgery) to 96.55mmHg (at the time of discharge).

Conclusion: The hip abductor muscle plays a consequential role in hip surgery. Its recovery is significant for the better functional outcome. Physiotherapy following surgery improves the hip abductor muscle strength.

Keywords: Avascular Necrosis, Osteonecrosis, Hip abductor muscle strength, Sphygmomanometer, Hip surgery.

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INTRODUCTION

Osteonecrosis, commonly referred to as avascular necrosis or aseptic necrosis, is a medical condition whereby bone tissue dies either gradually or suddenly due to an interruption in the blood supply to the bone resulting from any traumatic or non-traumatic event [1].

The mean age of patients in the northern Indian population experiencing femoral head avascular necrosis was 34.71 years. The ratio of men to women is 5:1. Approximately 61.61% of patients suffer from bilateral involvement in atraumatic situations. A combined percentage of 37.3% of patients exhibited chronic steroid administration, subsequently followed by idiopathic cause in 21.3%, chronic alcohol consumption in 20.1%, and sickle cell anemia in roughly 32.3% of cases. It has also been reported that individuals who experience unilateral involvement typically manifest the disease at an earlier stage, while those who experience bilateral involvement do so at an advanced stage [2].

Contributing factors that contribute to Avascular necrosis of the femoral head include hip trauma (femoral neck and acetabular fractures, hip dislocation, sprain, or contusion; no fracture, but on occasion intra-articular hematoma); high-dose glucocorticoid medication [3] utilized throughout a prolonged amount of time; heavy alcohol consumption over an expanded time frame of time; thrombophilia and hypo fibrinolysis; and autoimmune diseases treated with glucocorticoids [4,5]. The disease is frequently bilateral due to systemic risk factors; estimates suggest that up to 70% of individuals with unilateral osteonecrosis also experience disease in the contralateral hip [6,7].

Sickle cell disease-related ischemia and Vaso-occlusion in the bone result from clustering/precipitation of Haemoglobin S in low-oxygen conditions, comparable to the development of other vaso-occlusive damage (damage caused when small blood vessels become blocked). Osteonecrosis results from Vaso-occlusion, excessive blood viscosity, and concurrent alpha thalassemia. It is believed that alcohol consumption alters lipid metabolism and increases adipogenesis in those who drink. It has also been suggested that elevated lipid synthesis increases the risk of fat emboli obstructing blood vessels. Furthermore, marrow packing - which increases intraosseous pressure and decreases blood flow - may be brought on by elevated serum cholesterol levels. Drinking alcohol may have a role in the death of osteocytes. Furthermore, cortisol levels were significantly greater in patients with alcohol-induced osteonecrosis than in control people suffering from idiopathic osteonecrosis [6,8].

As per the MRI, in the early stage of osteonecrosis, there is necrosis of the bone tissue, but there is no damage to the subchondral bone or the surrounding normal hyaline cartilage. Subchondral fractures can occur in the later stages of the illness and may culminate in femoral head collapse, instability, and buckling of the articular cartilage beyond it. This may eventually result in end-stage secondary joint arthritis. Once the collapse has occurred, preserving the initial hip joint is often unattainable, or if tried to preserve, the results have been associated with discomfort and poor functional outcomes and subsequently develop into arthritis [9].

The initial indications of bone necrosis include discomfort in the hip joints and decreased range of motion. The primary characteristic of the discomfort begins in the groin region and is followed by pain that radiates to the thigh and buttocks. It is said that the pain is deep, rarely localized, and spreads down the leg to the knee, with the worst occurring at night. As secondary arthritis occurs, there is a restriction in ROM, crepitus, positive Trendelenburg sign due to weak hip abductor muscles [10], and pain in weight-bearing activities, i.e., painful ambulation. In the later stages of avascular necrosis, the femoral head and acetabulum deform, leading the hip joint to turn cylindrical instead of spherical and impairing hip abduction and rotation while maintaining flexion mobility [11-13].

Strengthening the hip abductor muscles is crucial, especially among individuals who have had hip surgery. While hip abductor weakness is frequently observed in patients who have had total or partial hip replacement surgery, weakness in this muscle over an extended period without hip strengthening exercises results in weakened surrounding hip joint structures, making it more challenging to maintain hip mobility. Hence, we determined to study the hip abductor muscle strength in patients with avascular necrosis of the femoral head.

METHODOLOGY

This prospective observational study was started after receiving the Institutional ethical approval (SVIEC/ON/PHYS/BNMPT22/APRIL/23/27). All the patients were recruited as per the inclusion criteria; those were patients with unilateral AVN of the femoral head and more than 18 years of age. We screened 85 patients of AVN hip joint, of which 65 patients were recruited, and the rest were excluded due to bilateral involvement of the hip joints or refusing to undergo surgery. All the patients willing to participate in the study signed the informed consent forms. All patients were provided with a participation information sheet outlining the important details of the study, such as its benefits, risks, procedure employed, confidentiality measures, and contact details, which helped the participants make informed decisions about whether to participate in the study. The patient was recruited based on convenient sampling. In our study, the assessor was blinded to the type of hip surgery to avoid any potential bias in measuring the strength of the hip. The hip abductor strength was measured using a sphygmomanometer (Diamond BPMR120 Deluxe Conventional Mercurial Type BP Instrument), a diagnostic tool commonly used to measure blood pressure [14].

The hip abductor muscle strength was measured at three different intervals: 1. At admission in the fracture ward (pre-surgery strength), 2. After the surgery on postoperative

day 03 (after removal of drainage tube/ suction ballet) and 3. At the time of discharge. Patients were asked to lie in the supine position. The therapist tied the cuff to her right hand, and the instrument was inflated to 60 mm of mercury. To measure hip abductor muscle strength, the cuff was placed at the lateral aspect of the distal thigh of the patient. The valve of the sphygmomanometer was closed to prevent any release of air. The measurement was started by asking the patient to move their leg according to the therapist's instruction. For hip abductor strength, the patient was asked to push the therapist's hand by bringing the limb out in abduction movement without rotating the hip. Patients were instructed to make their maximum effort. The therapist resisted the movement by maintaining the same position and did not allow the patient to do the movement. The maximum pressure exerted on the cuff will be then recorded. Patients were given 30-35 seconds of rest in between each trial. After each trial, the pressure within the cuff was released, and the cuff would again be inflated to 60 mm of mercury before commencing the subsequent trial. The average of these three trials was considered as the final measurement. The same was repeated for the sound limb to compare the muscle strength.

At every interval, the hip abductor strength was measured 3 times for both the lower limbs. The patients were given physiotherapy from the day of admission based on principles of DVT prevention, muscle strengthening exercises, prophylactic exercises, and gait training [14]. The detailed methodology mentioned above outlines the patients' participation and measurement technique, which motivates the reproducibility of the study. The muscle strength data were tabulated in Microsoft Excel for the data analysis. The data were analyzed using SPSS 26 Statistics software. The software ran an Independent t-test, which helped explore the differences between pre-surgery and post-surgery measurements. A descriptive analysis of demographic data was done. The significance level was declared at $p < 0.05$ for all the data analysis.

RESULTS

For the trial, 65 patients (54 Males and 11 Females) diagnosed with femoral head avascular necrosis were admitted to participate. The mean age of the subjects was 38.78 years, with variations among male and female patients. Twenty patients, or the majority, had a history of sickle cell anemia; three patients showed a history of using steroids; one patient had hypertension; one patient reported systemic lupus erythematosus; and forty patients didn't report any positive history. Findings also showed a high number of addictions among AVN patients. The patients' occupations differed, but most reported working in agriculture, that is, farming 39 of them - while six were housekeepers. Eleven students, six unemployed, one carpenter, one plumber, and one social worker (Figure 1). All the patients were discharged on the post-operative day 12 (POD 12) from the day of surgery.

Figure 1: Demographic data of patients

Variables	Mean/Number
Male	54
Female	11
Mean age	38.78 years
History of: Sickle cell anemia, using steroids, hypertension systemic lupus erythematosus	 20 03 01 01
No report of any positive history	40
Occupation: Farmers, Housekeepers, Students, Unemployed, Carpenter, Plumber, Social worker	 39 06 11 06 01 01 01

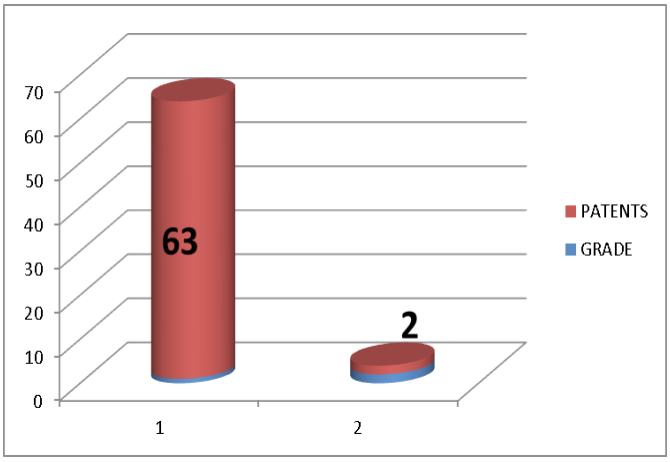


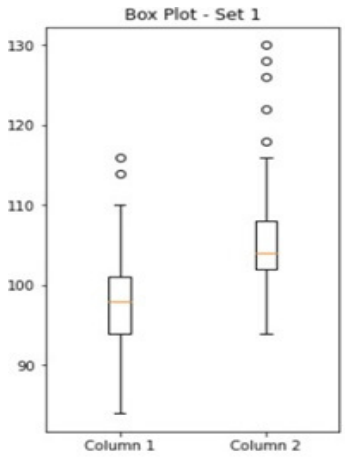
Figure 2: Distribution of Patients with Grade 2 and 3 of AVN of Femoral head

Table 1: Table Formulated to Show Comparative Independent t-test Values from pre-surgery to Post Surgery

Comparison	t – statistic	P – value
Pre-Surgery with POD – 3	17.8332	1.60
POD - 3 with Discharge	-14.0802	2.84

Table 2: Mean Values from pre-surgery to Post-Surgery

Pre-Surgery	97.43
POD –3	87.69
Discharge	96.55



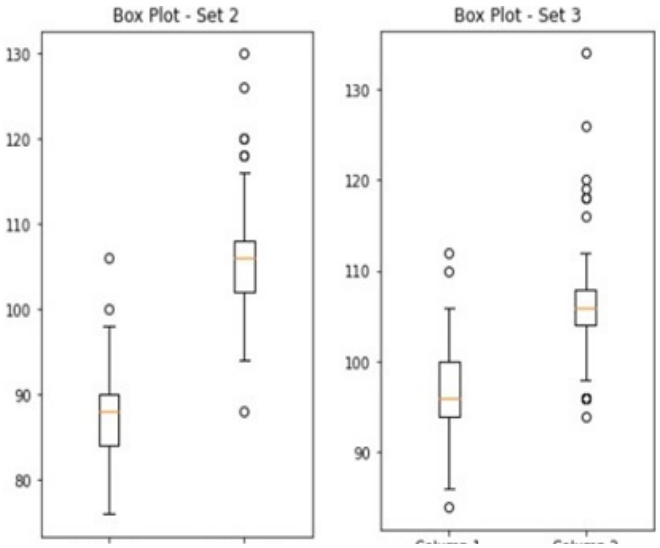


Figure 3: Mean Values Represented Using Box Plots From Pre-Surgery to Post-Surgery

Table 3: Table Formulated to Show Comparative Independent t-test Values from Pre Surgery to Post Surgery in Affected Versus Unaffected Side

Comparison	t - statistic	P – value
Pre-Surgery	-11.669	1.70
POD – 3	-21.3412	8.41
Discharge	-16.8023	3.75

Table 4: Mean Values From pre-surgery to Post-Surgery in Affected Versus Unaffected Side

Side	Pre-surgery	POD -3	Discharge
Affected Side	97.43	87.69	96.55
Unaffected Side	105.54	105.48	106.54

DISCUSSION

Avascular necrosis of the femur head is an irreversible pathology where secondary arthritis of the hip joint manifests, resulting in the deterioration of the joint and the muscles around it [15]. The hip abductors are spilled or retracted depending on the approach chosen by the orthopedic surgeon to operate on the AVN hip. This results in weakening of the hip abductor after the surgery. Hip abductor strength is significant for proper ambulation after THR or Hemiarthroplasty. We studied the hip abductor muscle strength of 65 patients with AVN of the femur head. To study the impact of surgery on the hip abductor muscle strength and the improvement in the strength after surgery, we chose to measure the hip abductor strength at three specific points in time: pre-operatively, on POD 3, and following in-patient rehabilitation until discharge, thus the third evaluation was taken at the time of discharge. The hip abductor muscle strength was measured using a sphygmomanometer. A previous study has demonstrated a moderate to high intra-rater reliability with intra-class correlation coefficient (ICC = 0.61 to 0.92) and high inter-rater reliability (ICC = 0.77 to 0.91) along with high concurrent validity (Pearson's r = 0.77 to 0.91) for the application of sphygmomanometer for hip strength assessment [14].

In our study, most patients were male in gender (83%) (Figure 1). We found a study by Vicaş et al. 2021 [16], which stated that AVN femur head was mainly seen in males in their study cohort. This was also supported by another study conducted by Prasad et al., 2020 [17], where 88% of males were in their study samples. We noted prevalence in our study, where one woman is suffering from AVN femur head for every five males. This shows notable gender disparity. We found a study done by Vardhan et al. 2012 [18] on the northern population of India, which studied the epidemiological profile of the people suffering from Avascular necrosis of the femur head, which resulted in a prevalence of five males to 01 female who suffered from an ANV femur head. Our patients' mean age was 38.78 years, ranging from 18 to 72 years. This observation corresponded with the study by Vardhan et al. 2012 [18] focusing on the AVN population, whose patients' ages ranged from 14 to 70 years old, with a mean of 34.71 years. Musculoskeletal discomfort was the most prevalent presentation of sickle cell disease (61.1%), which was initially identified in Indian tribal tribes in South and Central India. The prevalence of the sickle cell gene in India ranges from 9.4% to 22.2%, as studied by Colah et al., 2015 [19].

Our study reported that about 30.8% of cases presented a personal history of sickle cell anemia. In our cohort, we found a single patient who had systemic lupus erythematous (SLE). A study by George et al. 2022 [20] formulated that systemic lupus erythematous is a risk factor in avascular necrosis on the femoral head. It put forward that frequent corticosteroid treatment is linked to the relationship between SLE and osteonecrosis; nevertheless, a new investigation has revealed a greater frequency of osteonecrosis in patients with SLE compared to corticosteroid users without SLE, indicating potential synergistic effects. According to conflicting studies, the development of osteonecrosis in SLE may be impacted by the prothrombotic effects of antiphospholipid antibodies. Estimates of the prevalence of osteonecrosis in individuals with childhood-onset SLE ranged from 6 to 8.4%. The same study mentioned steroid use and showed that the second most recurring cause of osteonecrosis was the intake of steroids. Patients receiving large doses of corticosteroids had a ten times higher risk of developing avascular necrosis of the femoral head. Additionally, corticosteroids have been linked to decreased osteoblast proliferation and osteoblast mortality, which impede the body's capacity to replace and repair necrotic lesions.

According to Wali et al. 2011, [21], most patients had radiological grades 3 and 4 of AVN femur head as classified by Ficet and Arlet classification. Our study showed that 97% of patients showed grade 3 AVN femur head on a plain X-ray. We ran an independent t-test to compare pre-surgery hip abductor muscle strength with POD 3 and added POD 3 data with the data at discharge. We could not discover any statistically significant results in the data (Table 1). The measurement manifested that the hip abductor strength was reduced compared to pre-surgery

strength because of surgical pain and pain inhibition. When measured at discharge (96.55mmHg), the muscle strength showed improvement compared to POD 3 (87.69mmHg). This could be because of a reduction in pain and, thus, muscle inhibition due to pain. Also, the main reason could be in-patient rehabilitation, which started immediately post-operatively. However, the strength was not equal to the pre-surgery strength (97.43). However, the difference in the pre-operative strength and the strength at the time of discharge was negligible (Table 2, Figure 3).

As muscle strength, especially hip abductors, is known to be most commonly affected in patients after hip surgeries such as Total Hip Arthroplasty (THA), a study by Hu X et al. 2020 [22] on THR patients stated that THA alters the biomechanical characteristics of the hip abductor and adductor muscles, potentially leading to muscular weakening and reducing the efficacy of conservative rehabilitation. In their work, they also found that during the support phase, the operated side abductor muscle length was superior to those of the contralateral non-implanted side, suggesting that the THA side experienced less contraction of its abductor muscles. Reduced abductor moment and muscle efficiency resulted from these abductor's muscles' narrower moment arms compared to the contralateral sound side. Therefore, in-ward and outpatient physiotherapy is essential for the success of the surgery.

We compared the pre-surgery affected hip abductor strength with unaffected limbs' abductor strength. The difference in muscle strength was highly significant. Following this, we compared the affected hip abductor strength with the unaffected limb on POD3; the reduction in the strength showed high significance. Also, comparing the affected limb muscle strength at discharge with the unaffected limb, the improvement in the strength due to regular in-ward physiotherapy was highly statistically significant (Table 3). A study by Judd et al., 2014 [23] represented the functional outcome of patients post-total hip arthroplasty. After THA, patients' quality of life may decline 18 months later. Even while patients report less discomfort following surgery, persistent functional limitations that could be unacceptable with age indicate that postoperative outcomes could be better. Early on, following surgery, strength and function may change the most. Given that rehabilitation is likely to be advised during this period, knowledge of the deficiencies that exist right after surgery is necessary to decide whether or not to pursue rehabilitative intervention. This study found deficiencies in strength and outcomes scores one year after THA, which may indicate the need for modifications in postoperative care. The comparison group included healthy older persons.

Comparing the mean hip abductor strength of the affected and unaffected limbs at different time points showed that muscle strength was reduced after surgery. After taking physiotherapy till the time of discharge, the strength got improved. The improvement in the strength at the time of discharge was noteworthy as it almost reached the pre-surgical strength. However, the strength of the operated limb does not reach near the unaffected limb at any point in time (Table 4). This finding was supported by a narrative review of Patel N et al.,2018 [24] and the following studies. A study by Holm et al., 2013 [25] was undertaken to determine surgery-induced impacts on the functional outcomes after THA. It stated that despite initiating the rehabilitation immediately after surgery, the hip abductor muscle strength did not reach the pre-operative level when measured at various time points. Another study on THA by Fukumoto et al., 2013 [26] stated a conclusion with the presence of significant postoperative difference in the strength of the hip abductor muscle strength between affected and unaffected limbs at different time points of follow-ups. A similar study on muscle strength after THA conducted by Winther et al. 2018 [27} stated that they observed a 15% reduction in muscular strength at 3 months post-surgery in the operated limb compared to the unoperated limb.

CONCLUSION

The hip abductor muscle plays a consequential role in hip surgery. Its recovery is significant for the better functional outcome. Physiotherapy following surgery improves the hip abductor muscle strength.

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