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A Novel Multidisciplinary Approach: Hydrotherapy and XSENS Motion Analysis in Rehabilitation of Avascular Necrosis Post-Total Hip Replacement with apoplexy- A Case report

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Case Report

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Abstract

Background:

Avascular necrosis (AVN) of the femoral head is a progressive orthopedic condition that may require total hip replacement (THR) in advanced stages. Rehabilitation becomes more complex when compounded by neurological impairments such as stroke-induced hemiparesis. This report highlights a multidisciplinary approach involving orthopedic surgery, neurorehabilitation, hydrotherapy, and XSENS motion analysis in a patient with coexisting AVN and stroke.

Case presentation:

A 56-year-old male with a history of right femoral neck fracture managed previously with a vascularized fibular graft presented with chronic traumatic AVN (Grade IV) of the right femoral head. He also had residual left hemiparesis following a recent ischemic stroke. The patient underwent THR with intraoperative precautions due to neurological risks. Postoperatively, he experienced a tonic-clonic seizure, managed with antiepileptic therapy. A staged physiotherapy protocol, incorporating hydrotherapy and objective motion assessment via XSENS technology, was implemented to address both musculoskeletal and neurological deficits. The patient demonstrated gradual improvement in hip function, mobility, and independence in activities of daily living.

Results:

THR was successfully performed with minimal intraoperative complications despite the patient's complex history. Postoperatively, the patient experienced a tonic-clonic seizure managed with antiepileptic medication. The physiotherapy program facilitated gradual improvement in hip function and mobility, while addressing neurological deficits and promoting independence in ADLs.

Conclusions:

This case underscores the importance of a personalized, multidisciplinary rehabilitation plan in patients with coexisting musculoskeletal and neurological conditions. Early diagnosis, comprehensive surgical planning, and integrated postoperative rehabilitation can significantly improve outcomes and quality of life in complex cases like AVN with stroke-related hemiparesis.

Introduction

Avascular necrosis (AVN) of the femoral head is a progressive condition caused by disrupted blood supply, leading to bone death, structural collapse, and joint dysfunction (1). It is a significant contributor to hip pain and disability, often culminating in total hip replacement (THR) in advanced stages. In the

United States, AVN affects approximately 20,000–30,000 individuals annually, with trauma accounting for about 20% of cases. In India, while precise epidemiological data are scarce, AVN is estimated to constitute 10–12% of hip pathologies requiring orthopaedic intervention, particularly among the young and middle-aged. This demographic burden translates into considerable socioeconomic impact due to impaired mobility and productivity (2) .

The pathophysiology of AVN involves vascular compromise due to factors such as trauma, corticosteroid usage, excessive alcohol intake, and systemic conditions like sickle cell anaemia and autoimmune diseases. Traumatic AVN typically follows femoral neck fractures or hip dislocations, damaging the blood supply (3). Subsequent ischemia causes necrosis of bone tissue, a failed reparative response, and eventual femoral head collapse, leading to secondary osteoarthritis, chronic pain, and functional limitations.

Early diagnosis is critical but often delayed due to vague symptoms and minimal radiographic findings in initial stages. Magnetic resonance imaging (MRI) is the gold standard for early detection, identifying bone marrow oedema and necrosis before they appear on X-rays. Accurate staging informs treatment decisions, ranging from conservative options and joint-preserving procedures such as core decompression to THR for advanced disease.

THR is the definitive treatment in late-stage AVN, offering significant pain relief and functional restoration. However, in younger patients, concerns persist regarding implant longevity and the need for future revisions. Moreover, coexisting neurological comorbidities such as stroke add complexity to perioperative care, anaesthesia, and post-operative rehabilitation, necessitating a multidisciplinary approach.

Stroke remains a leading cause of long-term adult disability worldwide, with an incidence of 145–150 per 100,000 annually in India. Post-stroke deficits motor weakness, sensory loss, and cognitive impairments can significantly impede recovery following orthopaedic surgery. In patients with concurrent AVN requiring THR and recent stroke, clinical management becomes multifaceted, demanding synchronised orthopaedic and neurological strategies (4).

Rehabilitation plays a pivotal role in functional recovery in such complex cases. In this report, AQUA-MAX aqua therapy was utilised to initiate low-impact, resistance-based rehabilitation. Water buoyancy reduces joint stress while promoting strength, range of motion, and cardiovascular endurance (5). Additionally, XSENS gait analysis was employed to deliver precise, real-time feedback for gait training. This advanced motion-capture technology aids both therapists and patients in correcting gait abnormalities, enhancing proprioception, and improving walking patterns through data-driven intervention (6).

This case report highlights the interplay between chronic traumatic AVN of the femoral head and acute stroke, illustrating the clinical challenges and therapeutic considerations. It underscores the importance of early diagnosis, individualised surgical planning, and comprehensive rehabilitation, including modern

techniques like aqua therapy and motion-based feedback systems, to optimise recovery and quality of life in patients facing dual musculoskeletal and neurological impairments.

Case presentation

A 56-year-old male presented with progressive right hip pain, worsening over several months, especially during walking and prolonged sitting. He had a history of a right femoral neck fracture following a road traffic accident in 2008, treated with a vascularized fibular graft.

In December 2024, he experienced an acute ischemic stroke with a brief loss of consciousness and was admitted to Acharya Vinoba Bhave Rural Hospital (AVBRH). MRI revealed an acute infarct in the right fronto-parietal region and chronic lacunar infarcts. After discharge and alternative stroke care, he developed severe right hip pain. Imaging confirmed Grade 4 avascular necrosis (AVN) of the right femoral head.

Following neurological stabilisation, he underwent uncemented right total hip replacement (THR) in March 2025. On postoperative day 0, he had a tonic–clonic seizure. A CT scan showed a chronic infarct in the right frontal lobe. He was started on antiepileptics and began physiotherapy rehabilitation for post-THR recovery and neurological stabilisation. Timeline of events shown in Table 1.

Time-line of events

Table 1
Timeline of events

Dates	Events
2008	Road traffic accident resulting in a neck of femur fracture. Underwent surgery with a vascularized fibular graft in Sevagaram
2024	Developed right hip pain during walking and prolonged sitting. Consulted local practitioners and was prescribed painkillers.
December 1, 2024	Experienced an acute ischemic stroke with loss of consciousness for 4 hours. Taken to AVBRH, diagnosed with an infarct in the right fronto-pariteal region, chronic lacunar infarct in bilateral ganglio-capsular region following MRI, and admitted for stroke management.
December 8, 2024	Discharged from AVBRH after stroke management.
December 11, 2024	Aggravation of right hip pain. X-ray at a private clinic in Nagpur revealed Grade 4 AVN of the right hip. Advised total hip replacement (THR), but surgery was postponed due to stroke recovery.
March 4, 2025	Returned to AVBRH for management of hip AVN.
March 5, 2025	Pre-rehabilitation was initiated to prepare for total hip replacement surgery.
March 11, 2025	Underwent uncemented total hip replacement (THR) on the right side.
Evening of March 11, 2025	Experienced a tonic-clonic seizure (post-operative day 0) with up-rolling of eyes and tongue bite, managed by the emergency medical team
March 12, 2025	CT scan revealed a chronic infarct in the right frontal lobe. Medications were initiated for neurological management.
March 13, 2025	Post-operative physiotherapy rehabilitation began, focusing on muscle strength, joint mobility, gait retraining, and functional endurance for THR and Hemiparesis.

Clinical Presentation

A 56-year-old male, currently in the post-surgical recovery phase following total hip replacement (THR), presented with progressive right hip pain since 2024, described as deep, aching, and radiating to the groin, lateral hip, and gluteal region. Pain was aggravated by walking, prolonged standing or sitting, and relieved with rest and analgesics, with VAS scores of 34.7 mm at rest and 66.9 mm during activity. The patient has a history of type 2 diabetes and hypertension, both under control. On examination, he used a walker, indicating impaired balance and mobility, with muscle wasting, forward-leaning posture, and signs of fatigue. Posture assessment revealed forward head, rounded shoulders, thoracic kyphosis, reduced lumbar lordosis, posterior pelvic tilt, scapular winging, pelvic asymmetry, and sway-back posture. Gait was modified independent with antalgic features, asymmetrical midstance, poor push-off,

reduced toe clearance, shortened stride, and compensatory trunk movements. Joint-wise, there was limited ROM in the hip, knee, and ankle, right knee valgus deformity, and muscle wasting. The surgical site was clean with grade 2 tenderness along the suture line and warmth. Manual muscle testing showed bilateral lower limb weakness, more on the hemiparetic left side, with reduced strength in quadriceps, gluteal muscle, hamstrings, and calves. Girth measurements confirmed muscle atrophy; limb lengths were symmetrical with functional discrepancies due to postural adaptations. Neurologically, the patient was alert and oriented, with intact speech, normal tone on right side, preserved sensations and reflexes, and Brunnstrom stage 4 in the trunk, arm, and leg, and stage 6 in the hand of left side the following table summarizes the detailed ROM assessment (Table 2). A urinary catheter was in place due to a urethral stricture.

Range of motion:

Investigation:

Pre-operative radiographic evaluation of the right hip revealed significant degenerative changes with deformity of the femoral head, sclerosis, and joint space narrowing, consistent with Grade IV avascular necrosis (AVN) as shown in the pre-operative X-ray (Fig. 1), along with post-surgical changes from a prior fibular graft. The left hip showed early sclerotic changes suggestive of Grade II AVN. Post-operative X-ray confirmed successful uncemented total hip replacement (THR) on the right side, with well-positioned components and no signs of prosthetic loosening or dislocation (Fig. 2). MRI of the brain displayed acute infarcts in the right fronto-parietal region and chronic lacunar infarcts in the bilateral ganglio-capsular region shown in Fig. 3, consistent with ischemic stroke changes and small vessel disease, contributing to the patient's left-sided hemiparesis. These findings provided critical insight into both the musculoskeletal and neurological components of the patient's condition.

Surgical history:

Right total hip arthroplasty (uncemented) was done under spinal-epidural anaesthesia via a 10 cm posterolateral incision. After soft tissue dissection, femoral head dislocation, and neck osteotomy, the acetabulum was reamed to 58 mm and a 58 mm cup fixed with two screws. An uncemented femoral stem (06/135) with a 32 mm head (+ 7 mm offset) was implanted. Capsule and rotators were repaired, a drain placed, skin closed, and a knee brace applied. Patient shifted out.

Physiotherapy Management:

Comprehensive Exercise Protocol for Post-THR with Stroke Rehabilitation. The structured rehabilitation plan is detailed below (Table 3).

Table 3
Tailored Physiotherapy management

Phase	Timeline	Goals	Sample Exercises	Key Focus & Progression
Phase 1: Early Rehabilitation	POD 1 to Day 7	Alleviate pain and inflammation - Prevent complications (DVT, contractures) - Maintain joint mobility - Promote safe bed mobility and transfers - Begin ADL re-education	Diaphragmatic breathing - Ankle pumps and circles - Static quadriceps and gluteal sets - Gentle assisted ROM for hip - Bed mobility: rolling, bridging - Sit-to-stand with walker	- Begin exercises in supine or supported sitting - Monitor vitals, pain, and surgical site - Educate on hip precautions (avoid adduction, internal rotation, > 90° flexion) - Reps: 10–15, 2–3 times/day - Focus on patient confidence and safety
Phase 2: Controlled Mobilization	Week 2 to Week 3	Increase muscular strength and control - Improve hip joint mobility - Normalize early gait pattern - Enhance postural stability - Reinforce independence in ADLs	Active-assisted to active ROM - Bridging and pelvic tilts - Supported standing with weight shifts - Hip abduction with support - Seated marching - Gait training with walker	- Begin upright tasks under supervision - Progress ROM within pain-free range - Emphasize trunk control and postural alignment - Increase reps gradually (2 sets of 15) - Balance training on firm surfaces - Encourage short-distance walking with walker
Phase 3: Functional Integration	Week 4 onwards	Restore functional strength and endurance - Improve neuromuscular coordination Regain independent gait - Optimize dynamic balance and posture - Prepare for community mobility	Dynamic quad sets with resistance band - Standing hip abduction without support - Marching in place Forward and side stepping - Balance board training - Gait training with cane/crutch - Aqua therapy using AQUA-MAX - Gait training with XSENS for real-time feedback	- Transition from walker to cane/crutch as balance improves - Add resistance and dynamic challenges - Incorporate AQUA-MAX to reduce joint loading and ease movement in water - Use XSENS to correct gait in real-time through kinematic feedback - Introduce dual-tasking and community mobility (stairs, uneven surfaces) - Session duration: 20–30 min with increased intensity over time
Cardiopulmonary and Monitoring Throughout	Across all phases	Maintain cardiovascular endurance - Ensure safety during sessions -	Seated aerobic (marching, arm raises) - Progressive ambulation (timed	- Start with low-impact aerobic tasks - Use Karvonen Formula for Target HR (112–128 bpm) -

Phase	Timeline	Goals	Sample Exercises	Key Focus & Progression
		Educate on long-term self-care and energy conservation	walking) - Gentle cycling (later stages) - Deep breathing with arm movement	Check BP, blood sugar pre/post-exercise - Adjust plan for HTN/DM comorbidities - Include warm-up (5–10 min) and cooldown in each session

Legends: POD; Post-operative day, ROM; Range of motion, ADL; Activity of daily living, HTN; Hypertension, HR; Heart Rate. BP; Blood pressure, DM; Diabetes Mellitus

Figure 4 illustrates dynamic quadriceps training used in phase 3 rehabilitation. Figure 5 depicts exercise for neuro-recovery using Brunnstrom approaches.

Outcome Measure:

Measure	Score	Interpretation	Purpose
1. Visual Analogue Scale	At Rest: 34.7 mm (Mild Pain) On Activity: 66.9 mm (Moderate Pain)	0–4 mm: No pain 5–44 mm: Mild 45–74 mm: Moderate 75–100 mm: Severe	To quantify pain intensity both at rest and during movement.
2. Modified Harris Hip Score	21/91	Indicates severe functional limitation. Mean score reference: 78.97 ± 15.01 in Indian population	Assesses hip function post-THR based on pain, gait, and activities.
3. Lower Extremity Functional Scale	11/80 (13.8%)	0–20: Severe limitation 21–40: Moderate 41–60: Mild 61–80: Minimal	Evaluates physical function and disability in lower extremity conditions.
4. Barthel Index	45/100	Indicates moderate dependency in activities of daily living (ADLs)	Measures independence in personal care and mobility tasks.
5. Gait Analysis – XSens	Observational data (pre- and post-rehabilitation) collected using motion sensors	The gait analysis revealed a walking speed of 1.06 m/s and a cadence of 111.56 steps per minute. The patient took 33 steps over a duration of 17.75 seconds, covering a total distance of 18.33 meters.	Objectively tracks gait parameters like step length, cadence, trunk tilt, etc.

Discussion

This case underscores the importance of early diagnosis and accurate staging of AVN, timely surgical intervention, and a carefully coordinated neuro-orthopedic rehabilitation approach, especially in individuals with complex medical histories. It also highlights the need for anticipatory planning for post-operative complications in neurologically vulnerable patients to optimize recovery and minimize risks.

AVN of the femoral head is a progressive condition that often culminates in joint collapse and necessitates THR, especially in advanced stages. In this case, the patient developed post-traumatic AVN following a femoral neck fracture managed surgically with a vascularized fibular graft in 2008. Despite initial surgical intervention, the insidious re-emergence of hip pain and its progression to Grade 4 AVN illustrates the chronic nature of post-traumatic AVN and highlights the necessity for long-term follow-up in such cases .The complexity of this case was further compounded by an acute ischemic stroke several months before the scheduled THR. The resulting neurological deficits including hemiparesis, impaired

coordination, and Brunnstrom Stage 4 recovery necessitated significant adaptations in surgical timing, rehabilitation protocols, and outcome expectations. A tonic–clonic seizure in the post-operative period further emphasized the importance of close neurological monitoring and the integration of a multidisciplinary team comprising orthopaedics, neurology, internal medicine, and physiotherapy.

While standard post-THR rehabilitation protocols such as those described by Konnyu et al. (2022) promote early mobilization, progressive weight-bearing, and gait retraining, they often do not address the unique challenges of neurologically impaired individuals. Conversely, stroke rehabilitation guidelines, including those by (7)Li et al. (2024), emphasize neuroplasticity, bilateral training, and task-specific functional recovery tailored to hemi paretic patients. In this case, rehabilitation required a hybrid model, integrating orthopaedic and neurorehabilitation principles.

Early mobilization was approached cautiously to accommodate seizure risk and stroke-related deficits. Progressive weight-bearing was adapted based on both hip precautions and motor control limitations. Strength training was customized for bilateral involvement but focused particularly on re-educating the hemi paretic side through facilitation techniques and proprioceptive input.

AQUA-MAX aqua therapy was introduced in the later phases to safely restore functional lower-limb strength, improve cardiovascular conditioning, and promote gait symmetry in a reduced weight-bearing environment. The buoyancy and resistance of water allowed the patient to perform coordinated movements that were otherwise difficult on land, aiding neuromuscular control and joint mobility. According to Mahboubeh Ghayour Najafabadi et al aqua therapy has been shown to benefit stroke patients with orthopaedic impairments by enhancing balance and endurance and reducing fall risk while improving quality of life (8).

For gait retraining, XSENS motion analysis technology was employed to provide real-time biomechanical feedback on gait symmetry, trunk compensation, stride length, and joint kinematics. This objective tool enabled both the therapist and patient to visualize movement deficits, facilitating targeted corrections and enhancing motor relearning. XSENS systems have demonstrated reliability in capturing post-stroke gait deviations and improving outcomes via biofeedback-driven interventions (9).

Comorbidities such as type 2 diabetes mellitus and hypertension likely contributed to micro vascular compromise, aligning with the findings of Konarski et al. (2022), who emphasized impaired microcirculation as a risk factor for idiopathic and post-traumatic AVN (10). Additionally, Cui et al. (2020) noted that metabolic syndrome significantly increases perioperative complications in orthopaedic surgeries, necessitating tailored perioperative care (11).

In conclusion, this case highlights the necessity for individualized, multidisciplinary rehabilitation that integrates advanced technologies like AQUA-MAX aqua therapy and XSENS gait analysis, especially in patients with dual neurological and orthopaedic challenges. Such a tailored approach ensures safer recovery, functional independence, and improved quality of life.

Conclusion

This case illustrates the importance of individualized rehabilitation planning in patients undergoing THR with co-existing neurological and systemic conditions. Integrating elements of post-stroke neurorehabilitation with orthopaedic recovery protocols resulted in a safe, functional, and patient-centered pathway. The case emphasizes the value of multidisciplinary collaboration, long-term surveillance, and protocol flexibility to optimize recovery in complex clinical scenarios.

Abbreviations

ADL	Activities of Daily Living
AVBRH	Acharya Vinoba Bhave Rural Hospital
AVN	Avascular Necrosis
CT	Computed Tomography
DM	Diabetes Mellitus
DVT	Deep Vein Thrombosis
HR	Heart Rate
MRI	Magnetic Resonance Imaging
POD	Post-Operative Day
ROM	Range of Motion
THR	Total Hip Replacement
TFL	Tensor Fascia Lata
VAS	Visual Analogue Scale

Declarations

Ethics Approval and Consent to Participate: Informed consent was obtained from the patient.

Consent for Publication: Written informed consent for publication was obtained from the patient.

Availability of Data and Materials: Data supporting this case are available upon reasonable request.

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Table

Table 2 is available in the Supplementary Files section.

Figures

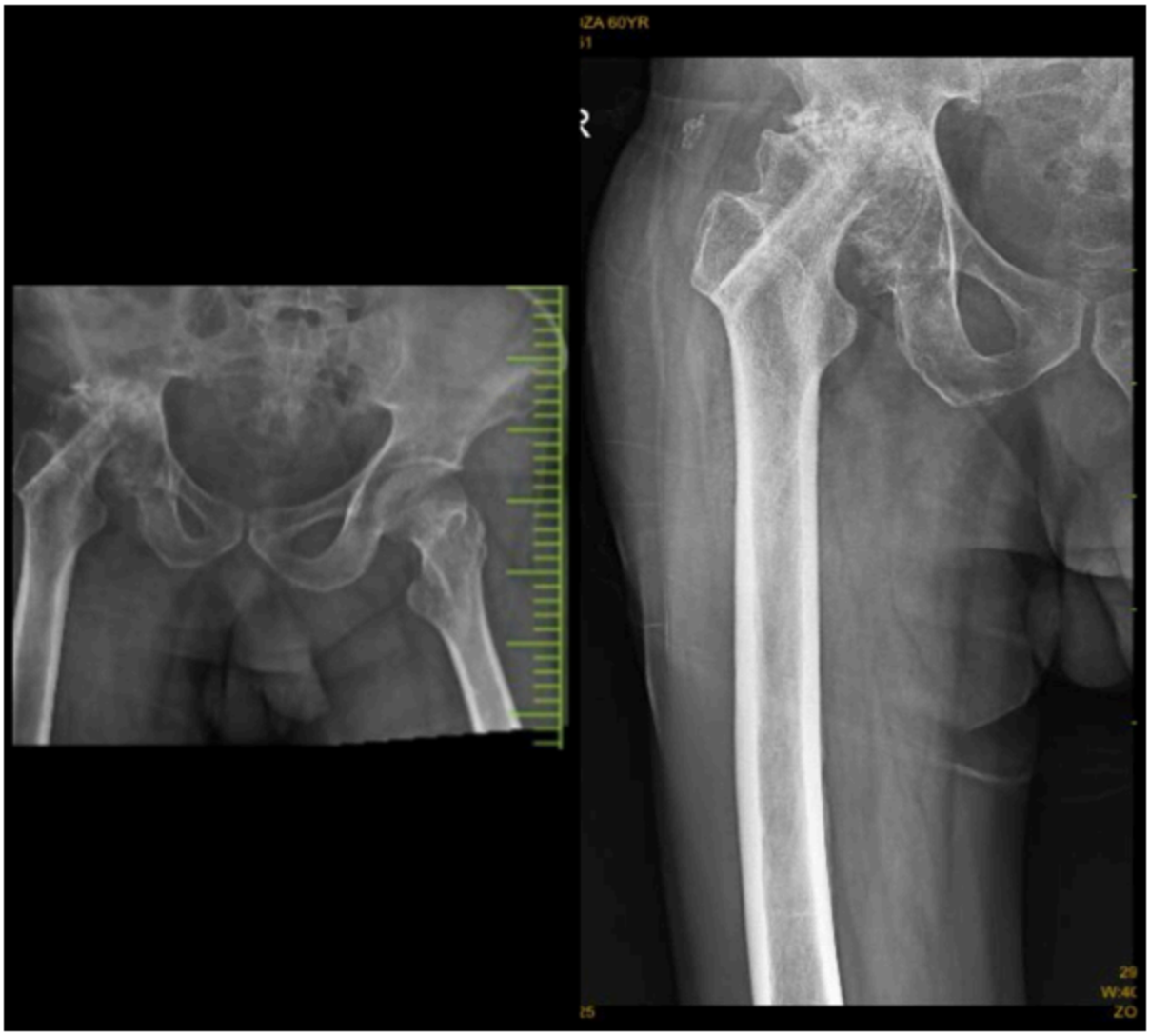


Figure 1

Pre-op X-ray shows Grade IV AVN in the right hip with deformity and sclerosis; left hip shows early AVN (Grade II) with mild sclerosis.



Figure 2

Post-op X-ray shows stable right THR with well-positioned prosthesis; left hip shows early degenerative or AVN changes.

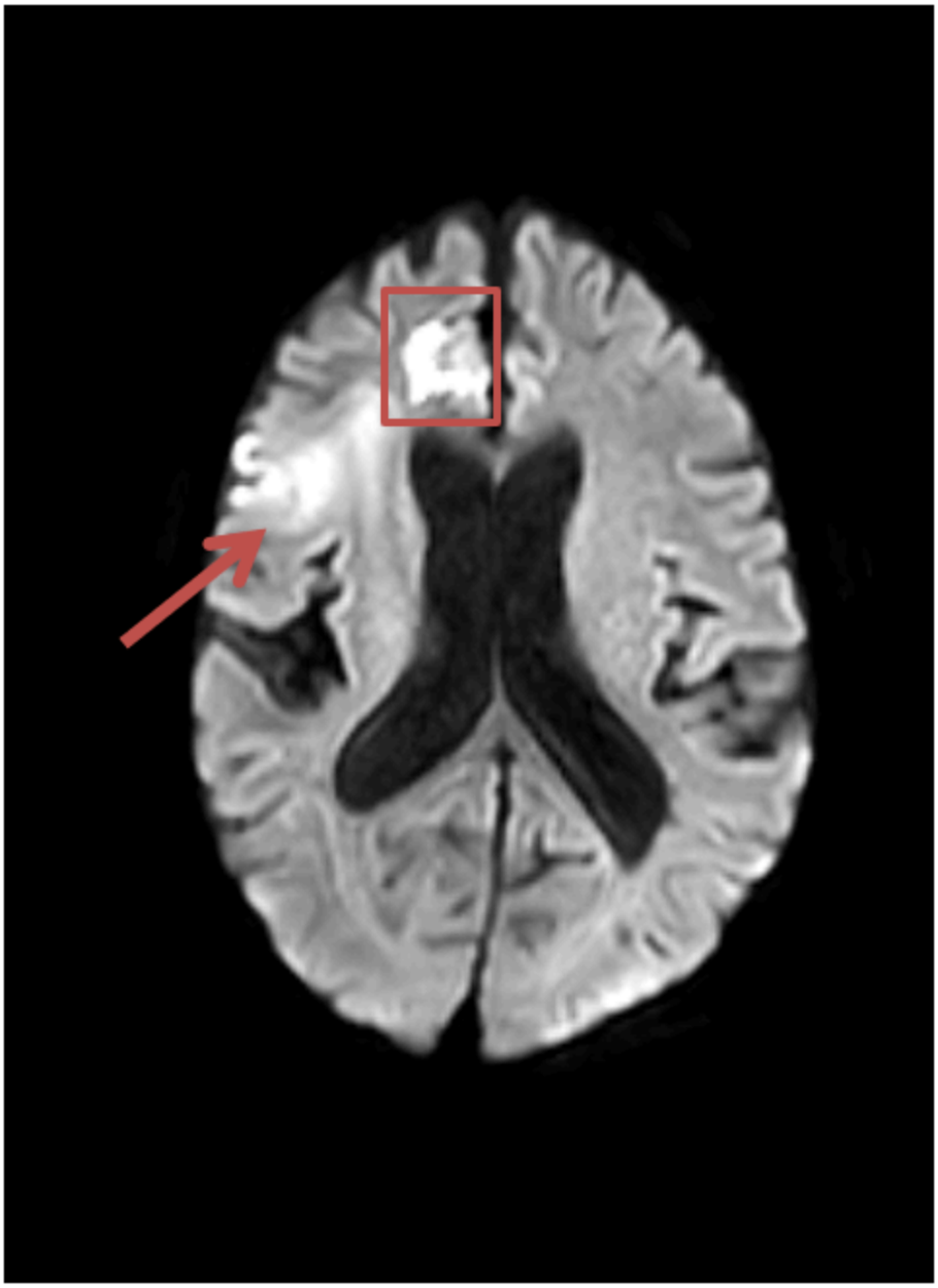


Figure 3

MRI brain shows chronic lacunar infarcts in bilateral gangliocapsular and left parietal regions, acute infarcts in right fronto-parietal region, and age-related atrophy with Fazeka's Grade II small vessel ischemic changes.



Figure 4

Dynamic Quads



Figure 5

Brunnstrom Approach

Supplementary Files

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- Tables2.docx