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Effectiveness of Neuro-Rehabilitation Approach in Lacunar Stroke – A Single Case Study

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***Abstract*: *Objective:* A 60-year-old male presented with chief complaints of dizziness, loss of consciousness along with tendency to fall on the right side followed by numbness. The patient reported the occurrence of symptoms were from 2 days. Patient has a known case of adhesive capsulitis on left shoulder since 6 months. *Intervention:* A combination of PNF and Bobath techniques followed by gait training and balance training. *Outcome:* Patient was able to walk in normal gait pattern and perform all the ADLs by 2 months of regular training. *Result:* The patient has shown marked improvement in muscle tone and strength. Improvement in range of motion and balance and co-ordination was also observed.**

***Keywords*: PNF, gait training, lacunar stroke, hemiplegia, Bobath technique, neural mobilization.**

1. Introduction

Stroke is among the most prevalent illnesses that causes functional impairment and disability. According to data from the American Stroke Association ischemic stroke accounts for 87% of all strokes with hemorrhagic stroke accounting for the remainder. Lacunar stroke is a kind of ischemic stroke. They are tiny and reside in non-cortical locations. Lacunar infarction are caused by the blockage of mall deep penetrating branches of the cerebral arteries from the circle of Willis such as the middle cerebral artery, anterior cerebral artery, posterior cerebral arteries and basilar artery [2]. Lacunar syndromes are clinical manifestation of a lacunar infarction. The damaged arteries branches at sharp angles from major vessels and are prone to constriction and sharp blockage. Penetrating arteries have no collateral and vary from 400µ to 900µ in diameter. Lacunar syndrome and infarction are frequently found in the basal ganglia (Globus pallidus, putamen, thalamus and caudate), pons and sub-cortical white matter structure (internal capsule and corona radiate). These anatomical locations are associated with lesions in the lenticulostraite arteries, anterior chorodial arteries, thalamoperforating arteries, paramedian branches of basilar arteries and Heubner's recurrent artery from the anterior cerebral artery. Many of the symptoms of lacunar syndrome are caused by lesion at these sires, the most frequent of which are motor hemiparesis, pure sensory stroke, ataxic hemiparesis, sensorimotor stroke and dysarthria-clumsy syndrome [1]. Two basic vascular diseases induce brain damage in people who have minor punctures of their brain arteries and arterioles. The first is arterial media thickening, followed by closure of the penetrating artery origin by Parent artery intimal plaques. The media of these small vessels may thicken as a result of fibrinoid accumulation and enlargement of smooth muscle and other connective tissue elements that support degenerative changes in patients with hypertension and diabetes, or they may contain foreign deposits as in amyloid angiopathy and genetically mediated ailments such as cerebral autosomal dominant arteriopathy with subcortical infarction and leukemia. Several pathogenic alterations arise in two distinct diseases. First, cerebral ischemia develops in areas fed by the damaged arteries. The ensuing lesions are minuscule infarctions that mostly affect the basal ganglia, pons, thalamus, and cerebral white matter. Second, fluid loss leads to swelling and gliosis in the white matter tract. Alterations in the media and adventitious tissue affect metalloproteinase and other compounds inside the vascular matrix resulting in a unique blood-brain barrier in these tiny veins [13]. Lacunar stroke is linked to other types of stroke such as hypertension, diabetes, advanced age, cigarette smoking and hyperlipidaemia. One of the most common symptoms among the causes listed is hypertension, in addition to usual risk factors; lacunar stroke can be caused by a rare genetic condition known as Cerebral Autosomal Arterioplasty with Sub-cortical Infarction and Leukoencephalopathy (CADASIL). These are typically accompanied by signs such as an elevated family history, and a conclusion is made using clinical suspicion and genetic testing. Lipohyalinosis is characterized as circumferential hyaline thickening of cerebral smaller vessels, resulting in the obstruction of tiny penetrating arteries. It constitutes one of the initial and most prevalent causes for lacunar stroke that has been characterized and pathologically validated. It is hypothesized to be caused by hypertension-induced hypertrophy and fibrinolysis of vessel walls. Branch atheromatous disease is a well-known pathological condition. Atherosclerotic plaques in the parent artery may come into contact with the ostium of perforating braches, resulting in distal parenchymal blockage and infarction. The use of this therapy has frequently been described in patients with luminal constriction of the parent artery in which case the lacunar stroke is defined as a consequence of cerebral atherosclerosis rather than small channel disease. Certain atherosclerotic plaques on the other

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hand can cause perforator disease even when there is no significant luminal stenosis. Other atherosclerotic processes discovered include embolism from a proximal intra-cranial or extra-cranial artery along with aortic arch disease. Cardioembolism is an uncommon complication of lacunar stroke. Atrial fibrillation can cause lacunar stroke because it worsen the white matter and promotes intrinsic Lipohyalinosis. Lacunar infarction corresponds to microscopic sub-cortical lesions having an ischemic aspect on CT or MRI, despite having been proven that minute puncturing arteries cannot be detected with routine imaging collection [6]. Neuro-imaging is used as an in-vivo proxy for a small brain infarction. The connection between clinical symptoms and radiological and histological data is not ideal. Despite the fact the patient had exhibited with a characteristic lacunar syndrome the presence of an acute cortical stroke on imaging ruled out SVD as the cause of the stroke. A small sub-cortical infarct on imaging on the other hand could indicate that it is related to anything other than arteriosclerotic SVD, such as embolism or large vascular atherosclerotic plaque. To clinical-radiological criteria the result of a perforating arterial blockage is defined as Recent Small Subcortical Infarction (RSSI) or White Matter Hyperintensity (WMH). Deep perforating arteries are now recognized as an end-terminal vascular area that supplies sub-cortical white matter and deep grey tissues. The basic hypothesis predicts that a perforating infarction of all tissue fed by the clogged puncturing artery will be blocked within a few minutes of occlusion. Nevertheless, around 20% of patients with a lacunar stroke had a transient ischemic event in the preceding hours or days, and those with a lacunar syndrome may recover with minimal brain damage on imaging. Specific plasma biomarkers can be utilized to identify the underlying pathophysiological mechanism involved in cerebral SVD which includes coagulations/fibrinolysis processes, endothelial dysfunction and inflammation. The pro-thrombotic conditions of patients with lacunar stroke are indicated by elevated levels of tissue plasminogen activators (TPA), plasminogen activator inhibitor (PAI), fibrinogen and D-dimer than those with no stroke but fewer than other stroke sub-types with larger infarction volumes. In a similar manner endothelial stimulation markers and leukocyte adhesion molecules are increased in individuals with lacunar stroke compared to healthy controls, but not in other subtypes. Several plasma inflammatory markers have been markers have been investigated in people with SVD. CRP, an accurate but not a comprehensive measure of systemic inflammation appears to be associated with the risk of stroke in people of all ages. Ischemia recurrence in patient with inflammatory indicators such as TNF-α and IL-6 has been seen. Most inflammatory markers are identical if not lower than the majority of indications [3]. A patient with an acute lacunar infarction outside of the TPA period who experiences a non-cardio-embolic stroke should get Dual Antiplatelet Treatment (DAPT) with aspirin and clopidogrel beginning within 24 hours of symptoms onset and lasting 21 days. DAPT in the acute phase effectively prevents recurrent ischemic stroke for 90 days after symptoms appear. Antiplatelet therapy for patients who have had TPA should be postponed for 24 hours. Permissive hypertension is permitted until the blood pressure is sufficiently raised. In that circumstance, decrease blood pressure by 15% over the first 24 hours and keep any outpatient antihypertensive medication upon admission for the first 24 hour unless another concomitant condition mediate blood pressure reduction. Lowering blood pressure below 185/110 mmHg is beneficial for TPA recipients. The purpose of blood sugar regulation is to maintain euglycemia which is defined as a blood glucose level of 60-180 mg/dL. Both hypoglycemia and hyperglycemia should be monitored. The desired HbA1c range is 65-7. Right volume status by providing isotonic saline as stroke patients are frequently volume depleted. Maintain oxygen saturation values over 90%. Continue taking statins with a target LDL of less than 70 mg/dL. Primary stroke preventive techniques include risk factor therapy with antihypertensive medicines, diabetes management and cholesterol-lowering agents. Smoking cessation, nutritional intervention, weight loss and physical activity [1]. Neurological rehabilitation is a particularly delicate area of physiotherapy because therapists must give significant physical support to patients during treatment. Working posture assessments have shown neurological physiotherapy as a substantial risk factor for musculoskeletal issues. The ideology that physiotherapists follow essentially determines their therapeutic procedures [8]. A physiotherapist spends significant amount of time in the rehabilitation of the patients after a stroke using several kinds of techniques. The Bobath concept has gained widespread attention as a ground-breaking approach to stroke rehabilitation. The goal of physiotherapy applying this paradigm aims to retain regular motion by modulating a variety of afferent signals the majority of which are proprioceptive. [15] Current therapy is predicted on three basic assumptions: a systemic perspective of motor control, neuroplasticity shaped by afferent input modification and neurophysiological dysfunction as the primary cause of movement dysfunction. These hypotheses are then compared to current knowledge of how mobility is altered in both normal and brain-damaged people following a stroke. The basic goal of stroke treatment is to regain full functional capacity in daily duties as well as personal and social identity. Stroke is the major cause of functional disability and the most common reason for rehabilitation for those over 60 years of age.

2. Review of Literature

Venkataraman et al. 2024 lacunar syndromes are clinical manifestation of lacunar infarction that affect arteries at an acute angle to major vessels. Their diameter ranges from 400μ to 900μ rendering them prone to constriction and obstruction. The term ‘lacune’ often refers to a tiny, chronic cavity but in some cases it can be caused by a severe infarction or intra-cerebral haemorrhage. More than 20 lacunar syndromes have been identified with common symptoms including pure motor hemiparesis, sensory stroke and dysarthria-clumsy hand syndrome. Lacunar syndromes are connected with two arterial pathologies: media thickening which reduced artery diameter and occlusion and origin obstruction as a result of micro-atheroma formation. Chronic hypertension, diabetes and genetic variable enhance medical thickening which causes

occlusion issues in penetrating arteries resulting in small violations. Lacunar infarction requires rapid treatment similar to acute ischemic stroke with intravenous altaplase administered within 4.5 hours of symptoms onset. Previous stroke gastrointestinal cancer, brain surgery and intra-axial intra-cranial tumour are all contraindicated. Individuals who are not eligible for IV altaplase should get aspirin. Secondary prevention involves of aggressive blood-pressure control, high-dose statin medicine and anti-platelet treatment. The best treatment is three weeks dual anti-platelet therapy followed by single anti-platelet. Current recommendations include anti-platelet medications, aggressive blood-pressure control, high-dose statin, and blood sugar control, smoking cessation, salt reduction, weight management and lifestyle adjustments. Early rehabilitation is crucial for stroke particularly lacunar syndrome and should include physical medicines, therapy, behavioural intervention and occupational care to improve overall prognosis.

Gore et al. 2023 stroke is a common illness that causes impairment and is primarily ischemic accounting for 87% of all cases. Lacunar stroke, non-cortical infarctions caused by deep penetrating branches of the cerebral arteries are symptomatic. Having multiple small transgressions might result in significant physical and cognitive disabilities. The vascular system that creates the Willis circle is responsible for the bulk of cerebral circulation. The principal cerebral branches re the middle cerebral artery, anterior cerebral artery, posterior cerebral artery, basilar artery and vertebral arteries. Minor arterial blockage Lipohyalinosis results in the formation of microatheromas. Lipohyalinosis is caused by hypertension, diabetes and other risk factors whereas microatherma is an atheromatous vascular lesion of the brain parenchyma. Other causes of sub-cortical stroke include foreign deposits in the arterial medium and genetic disorders such as cerebral autosomal dominant arteriopathy with sub-cortical infarction and leukoencephalopathy. Other probable causes of mild cerebral infarction include embolism, vasculitis, infection and vasospasm none of which have been proven y autopsy. Lacunar infarctions which are typically asymptomatic occur frequently in deep brain nuclei such as the thalamus, basal ganglia, pons and internal capsule white matter. They might be symptomatic or symptomatic nevertheless, silent lacunar infarctions are more common. The clinical presentation varies according to the area of brain involvement with some cases culminating in severe hemiplegia. There are around 20 distinct types of lacunar syndrome with the most common being pure motor hemiparesis, ataxic hemiparesis, pure sensory stroke, dysarthria and sensory-motor lacunar stroke. These disorder accounts for 45% of cases, with atypical hemiparesis accounting for 10% to 18%. Sub-cortical stroke is common with more than 40% deteriorating neurologically within a week of presenting symptoms. Lacunar stroke are a leading cause of vascular dementia and mild cognitive impairment. Because of their small size, lacunar ischemia injuries are seldom diagnosed within 24 hours using a CT scanner. Lacunar stroke when apparent appears as ill-defined hypodensities. Early infarction symptoms include loss of gray-white differentiation and localised hypoattenuation of the brain parenchyma. A CT angiography cans identify filling defects, artery constriction and serious vascular disease. Neurovascular imagining is essential to detect significant arterial blockages and carry out catheter-guided thrombolysis. MRI is a better imaging method for detecting lacunar infarction with MRI diffusion-weighted images (DWI) providing the most accurate diagnosis is an acute from chronic lesions. Primary and secondary stroke prevention is crucial in treatment plans. Primary prevention entails treating risk factor such as hypertension medication, diabetes management, and cholesterol-lowering medicines and so on. Secondary preventative approaches include antithrombotic medications and the treatment of underlying risk factors. Oral anticoagulants are not advised to prevent minor cerebral vascular disease-related strokes. Lacunar stroke is the leading cause of vascular dementia and cognitive impairment with physical disability-related complications such as aspiration pneumonia and deep vein thrombosis. Pulmonary embolism, urinary tract infection, depression and decubitus ulcers.

Rudilosso et al. 2022 lacunar infarctions are one of the most prevalent kinds of ischemic stroke and may be the first visible symptoms of cerebral small vessels disease, a degenerative condition affecting the brain's small perforating arteries, capillaries and venules. Several pathophysiological factors that lead to perforating artery blockage are diverse however they are not fully understood due to spatial resolution limitations in neuro-imaging a shortage of pathogenic research as well as a scarcity of good experimental models. Recent breakthroughs in endovascular treatment of large artery blockage may have shifted attention away from the handling of patients with small vessels occlusion who are typically omitted from clinical studies of acute and preventative measures. Early identification reperfusion treatment and secondary preventive measures on the other hand benefit those suffering from lacunar stroke. Furthermore, major advances in our understanding of this entity lead to the potential advantages of thrombolysis in a longer time frame in certain patients as well as innovative treatment strategies targeting distinct pathophysiological pathway involved in small artery disease. This review gives a compressive update on lacunar stroke causation and clinical therapy drawing on the most current imaging and translational studies.

Nguyen et al. 2022 stroke individuals in the ongoing stage of more than six months after stroke onset usually demonstrate lasting impairments in motor skills and muscle co-ordination which can lead to gait and balance control issues. These deficits have a significant impact on daily functioning, quality of life and increase the likelihood of falling. Chronic stroke therapy should aim to correct unequal postural behavior in stroke survivors by increasing balance control of motor processes that facilitates walking. This can be performed by muscles re-education on either of the damaged and unaltered sides resulting on enhanced motor function and sensory input. Post-stroke rehabilitation methods such as cycling, treadmill walking and functional electrical stimulation can assist stroke patients to improve pain, range of motion, muscle strength, endurance, and co-ordination along with functional progression. Although PNF

has been shown to improve gait-related outcomes, meta-analyses do not give sufficient evidence to judge its efficacy. A clear and accurate overview of the effectiveness of PNF-based training on balance and gait in chronic stroke patients is presently unavailable. This study conducts a comprehensive and meta-analytical review of current RCTs to explore the advantages of PNF on improving balance and gait abilities in patient with chronic stroke alone, excluding those in the acute and sub-acute phases following stroke. This meta-analysis examines the 10 Minute Walk Test, the Berg Balance Scale, the Functional Reach Test and the Time Up and Go Test in patients with chronic stroke. The findings are similar with previous findings from acute and sub-acute stroke patients but they are further highlight the benefits of PNF intervention in correcting impaired balance and gait. PNF sprinters and skaters practice neck, scapular and pelvic pattern while lying on their sides as well as bilateral limb movements. The favorable findings indicate that PNF may help with fundamental muscular administration, which enhances equilibrium by co-coordinating movement and providing a proprioceptive sense of muscles and tendons. The PNF exercise programme has a spiral, diagonal orientation, stressing functional training on trunk stability with the purpose of increasing lateral balance. The major goal of therapy appears to be to restore lateral trunk balance which was more severely damaged by stroke than anteroposterior balance. PNF intervention improves lateral, static and dynamic balance in chronic stroke patients hence enhancing functional balance and mobility. Some studies have found that stability may be an indication of gait performance in people with chronic hemiparetic stroke showing a link between balance and gait features. This assessment includes four trails that indicated the significant advantages of PNF on improving balance and gait speed in people with chronic stroke. PNF enhances pelvic control that is required to maintain trunk control, gait and balance by enhancing muscle and joint proprioception. Patients with stroke may benefit from specific core-stability therapy to enhance not just trunk function but also balance and mobility. The PNF pelvic pattern was widely used in gait training programme designed to improve core stability and ambulation in stroke victims.

Song et al. 2021cerebrovascular disease affects stroke survivors causing both physical and cognitive issues and stroke patients suffer from illness-related symptoms that impair their physical and cognitive capacities in everyday life. Stroke survivor experience physical difficulty with speech, balance, coordination, walking and vision as a result of hemiplegia which is one of the most severe and long-term effects and these concerns can leads to despair and a low quality of life. The symptoms differ based on the location and size of the original stroke lesion in the brain making recovery more difficult and unique to each person. As a result, multidisciplinary approach is essential for establishing successful stroke rehabilitation programme that can meet a wide range of demands on stroke survivor's physical, social, cognitive and psychological functioning. Tai-chi an ancient Chinese martial art is a low-intensity aerobic training routine characterized by clam, smooth and continuous body motions. It offers psychological benefits because to the Taoist mind-body link which enhances physical health soothes the mind and decrease fall and stress.

Yaghi et al. 2021 a lacunar strokes a sub-cortical infarction of less than 20mm in diameter in indicative of cerebral small artery disease and accounts for upto 25% of all ischemic strokes. It is caused by liquefactive necrosis and has potential diagnostic and therapeutic uses. Hypertension, diabetes, advanced age; cigarette smoking and hyperlipidemia are all complications for a lacunar stroke. A rare genetic disease known as CADACIL may also causes lacunar stroke. Lipohyalinosis is a frequent cause of lacunar stroke characterized by concentric hyaline thickening of cerebral small capillaries, resulting in penetrating artery occlusion. It results from hypertension-related hypertrophy, fibrinoid degeneration and subintimal foam cells. It causes infarction that ranges in size from 3 to 7 mm on brain imaging. Atherosclerosis is common in people who have luminal constriction of the parent artery and particular plaques causes' perforator disease in the absence of significant luminal stenosis. Cardioembolism processes are unlikely to generate a mild subcortical infarction. Patient with atrial fibrillation with lacunar stroke had more severe white matter damage.

Gandhi et al. 2020 during the immediate time following a stroke 60-80% of victims experience upper or lower motor impairments. Only 20% of severely paretic stroke patients recover complete upper extremity activities compared to 80% of somewhat paretic survivors. 50% of stroke patients who first present with paralysed both their upper and lower limbs regain motor functions. Painful upper limb particularly around the shoulder as well as complicated regional pain syndrome-type 1 are described by around 50% of stroke survivor in the initial year following stoke impacting their everyday activities. Around 40% of those with an acute right hemisphere stroke exhibit hemineglect namely lack of sensory attention which decreases to 15% and 5% respectively by the third month. Spatial neglect has harmed functional recovery and is associated with a worse quality of life. Long-term functional recovery is also closely related to initial level of paresis. To encourage recovery through neuroplasticity rehabilitation treatment must be repetitive, intense and task-oriented. According to finding improved exercise therapy improves ADL function considerably when begun between 16 hours and 6 months following a stroke. Mirror therapy (MT) unlike other treatment modalities that need a certain amount of independent motion can be employed in completely paralysed or severely paretic stroke patients because it uses visual rather than cutaneous cues to elicit an optimal response in the afflicted limb. Mirror therapy is a protocol that uses the mirror on moving the normal limb to provide the illusion of movement in the afflicted limb. This is conducted by placing a mirror between the arm and legs. MT has been shown to treat not just a motor deficiency but also sensation, visuospatial neglect and pain after stroke. MT is a neurophysiological phenomenon defined by the presence of a mirror neuron system in the frontotemporal region and superior temporal gyrus that discharges with goal-directed hand actions, hence improving motor performance and learning. MT also aids in the recovery

from lack of activating the Superior Temporal Gyrus, precuneus, and Posterior Cingulate Cortex, hence improving attention and sensation. MT is a successful technique to improve after stroke impairment in the acute, sub-acute, and chronic stages. The incorporation of bilateral arm training improves patient response to MT. The appropriate dosage of MT, as well as the long-term effects and implications on Activity of Daily Livings and Quality Of Life on various subtypes of stroke, must be extensively researched in bigger populations.

Sparkes 2000 The EC Manual Handling Operations Regulations (MHOR) were designed to prevent workplace accidents caused by inappropriate lifting procedures. Nursing is a fragile profession, with a significant risk of low back discomfort due to patient handling obligations. The Royal College of Nursing issued a manual handling guideline to safeguard nurses. However, little study has been conducted on manual handling techniques and the prevalence of low back discomfort in physiotherapy, particularly neurological rehabilitation. Treatment procedures are not fully investigated in the UK, resulting in inadequate supervision of physical handling practices.

Moncion et al. 2020 Stroke is a prominent cause of neurological impairment worldwide, often as a result of a sedentary lifestyle and insufficient aerobic capacity. Aerobic exercise is critical for neuroplastic repair and functional independence, and it may help avoid inactivity. As a result, aerobic exercise-based rehabilitation is recommended after a stroke. Aerobic exercise is crucial in professional practice, but its application in stroke rehabilitation varies due to limitations such as a lack of resources, screening tools, and knowledge gaps. Inconsistencies result from the complex interplay of patient-clinical characteristics and practice setting-related variables. The Theoretical Domain Framework (TDF) helps healthcare workers identify and categories barriers and facilitators to evidence-based practice. It consists of 14 domains: information, skills, memory, attention, decision-making processes, behavioral control, social/professional role, belief, intents, objectives, reinforcement and emotions, environmental context, and social influences. Theory-driven research using the TDF can help evaluate obstacles and facilitators impacting aerobic exercise regimens in stroke patients, as well as design behavior change methods to increase adoption in clinical practice.

Veldema and Jansen 2020 the major purpose of this comprehensive review and meta-analysis is to consolidate available data on water treatment in stroke rehabilitation and assess its efficacy in encouraging stroke recovery. The PubMed, Cochrane Central Register of Controlled Trials, and PEDro databases were searched from their inception to May 31, 2020, for randomized controlled trials assessing the efficacy of aquatic therapy on stroke recovery. Subject profiles, methodological elements, and intervention descriptions and results were gathered. The magnitude of effects was computed for each research and end-point. When compared to no intervention, water therapy improves walking, balance, mental state, overall quality of life, stiffness and biochemical markers. When compared to land-based treatments, water therapy improves balance, walking and muscular strength, proprioception, health-related quality of life, physiological markers, and cardiorespiratory fitness. Only when people are self-sufficient in their daily lives can land and water-based exercise produce comparable outcomes. Established conceptions of water-based therapy are the most useful, whereas aquatic treadmill walking is the least effective. There is insufficient evidence to support this therapeutic, evidence-based therapy.

Carey et al. 2019 Neuroplasticity refers to the nervous system's ability to reorganise its structure, function, and connections in response to inputs. It is related with growth and learning and may be influenced by experience and circumstance. Meaningful conduct is one of the main motivators. Evidence of neuroplasticity may be established at many different levels, albeit its use in treatment results is still in its early stages. Stroke impairs daily activities, sensation, mobility, cognition, psychological functioning, and independence. While there may be recovery and recovering lost abilities, rehabilitation outcomes are average and variable, with little evidence supporting innovative treatments. Neuroplastic changes generated by brain trauma, such as a stroke, can be helpful or deleterious. However, there is a gap in taking advantage of this opportunity for continual healing, highlighting the need for focused rehabilitation to boost these neuroplasticity mechanisms. Brain plastic changes are both experience-dependent and learning-dependent, and they can be sculpted by stroke events and later affected by rehabilitation, stressing the need of learning and evaluation in attaining brain plasticity. Neuro-rehabilitation, a kind of stroke therapy based on neuroscience, tries to enhance adaptive learning while also providing restorative benefits. Understanding the mechanisms that encourage or solidify this plasticity will help in the development of neuroscience-based treatments. The goal of our scoping study was to look at information on brain plasticity, stroke healing, and learning, as well as their interrelationships and interactions, in order to enhance the neuroscience behind stroke rehabilitation and recovery. The study looked for evidence of neuroplasticity changes at the cellular and brain network levels, such as synapse remodelling and functional connectivity. It focused on stroke recovery outcomes, including disability, performance, participation, and quality of life. The study also looked at the relationship between learning experience, brain plasticity, and stroke outcome, seeking to determine whether different learning experiences may contribute to a better stroke result. The goal of this study was to uncover literature that links neuroplasticity, stroke recovery, and learning to improve an educated approach to stroke rehabilitation. The idea map produced by the text processing engine is an efficient and rigorous way for detecting connections between various research topics.

Mikolajewska 2017 Stroke is the leading cause of mortality and long-term disability, with ischemic stroke accounting for 70–80% of all cases. Post-stroke gait issues restrict a patient's mobility freedom and participation in everyday duties, reducing their efficiency. These assessments can assist determine the

efficacy of gait function restoration in neurorehabilitation programme. The Bobath neuro-development treatment (NDT Bobath) for adults remains a popular approach of neurorehabilitation, including gait re-learning. Current research on its use in post-stroke gait relearning has methodological hurdles. There is inadequate evidence from randomized controlled trials (RCTs) to demonstrate that a certain physiotherapy method, such as NDT-Bobath, is more effective than other treatments for gait rehabilitation. Combining NDT-Bobath with other procedures may impair the efficacy of the previously described image. Rehabilitation using a mix of treatments to improve gait function following a stroke. Research into mixed/eclectic approaches is crucial for patient-specific treatment. There is currently minimal evidence on the use of NDT-Bobath procedures in conjunction with other therapeutic modalities. However, the effective combination of rehabilitative methods, task practice-based therapy, and botulinum toxin injections resulted in enhanced post-stroke gait recovery. The study revealed that combining NDT-Bobath with a traditional approach is more useful than utilizing a traditional strategy alone for post-stroke gait rehabilitation; however, the results require more research and in-depth analysis due to the limited sample size and rapid rehabilitation effects. The proposed technique may eliminate bias and imprecision in gait neurorehabilitation in post-stroke patients. The findings might be used in clinics to improve the reputation of the NDT-Bobath approach. A randomized experiment is planned to assess long-term rehabilitative effects. More study on recovery predictors is needed, as is improved techniques such as semi-automatic parameter extraction from digital data. The NDT-Bobath approach improved post-stroke patients walking abilities more than standard treatment. It improved body balance more than the PNF approach and did not need hand paresis, demonstrating in usefulness in gait re-education. Post-stroke patients walking distance improved after three weeks of NDT-Bobath rehabilitation although the motor relearning programme (MRP) was more beneficial in acute stroke rehabilitation comparable to the outcomes of robot-based treatment.

Caplan 2015 small penetrating brain arteries and arterioles cause brain damage due to two major vascular pathologies: arterial media thickening and parent artery intimal plaque obstruction. These changes can produce cerebral ischemia, deep micro infarctions, and fluid leaking, resulting in edema and gliosis in white matter pathways. These alterations affect metalloproteinase and cause an abnormal blood-brain barrier, leading in chronic gliosis and white matter atrophy.

Amela et al. 2015 the major objective of stroke rehabilitation is to regain optimum functional capacity in everyday activities while preserving personal and social identity. To evaluate the functional recovery of individuals with anterior circulation syndrome, posterior circulation syndrome, and lacunar syndrome after their first ischemic stroke during the acute and post-acute stages of physical therapy and rehabilitation. A stroke patient underwent an 8-week rehabilitation plan at the Clinic of Physical Medicine and Rehabilitation. Six months later, they were retested with the Motor Assessment Scale (MAS) to monitor their motor and functional recovery, with an emphasis on hand recovery and overall functioning. The study revealed that those with lacunar syndrome, as well as those with anterior and posterior circulation, recovered much better functionally after physical therapy and 6 months after a stroke. This was particularly evident in patients with lacunar syndrome and posterior circulation stroke, who demonstrated significant increases in motor recovery and overall functioning when compared to those with posterior circulation. Patients with lacunar syndrome recover more functionally from their first ischemic stroke than those with anterior or posterior circulation syndromes during acute and post-acute physical therapy and rehabilitation.

Lennon 1996 a stroke is among the three-leading cause of death in adults and costs a significant portion of healthcare spending. A physiotherapist spends a large amount of time treating patients after a stroke using a range of rehabilitation techniques. Physiotherapy utilizing this paradigm aims to re-educate normal movement by changing a range of incoming inputs, and more than half of which are proprioceptive. Recent articles have criticized this approach for failing to integrate new information into its conceptual framework. The purpose of this research is to examine the existing research on physiotherapy that employs the Bobath concept in rehabilitation following a stroke. The present approach is based on three fundamental assumptions: a system-level view of motor control, neuroplasticity shaped by afferent input alteration, and neurophysiological dysfunction as the major cause of movement dysfunction. These assumptions are then tested against existing understanding of how mobility is governed in both normal and brain-damaged patients following a stroke.

3. Case Report

A 60-year-old right-handed man resident of Greater Noida appeared with major symptoms of dizziness, loss of consciousness, and a tendency to fall on the right side, followed by numbness lasting two days. There have been no complaints of slurred speech or dysphagia. He has a 15-year medical history of type 2 diabetes mellitus and hypertension, for which he was prescribed medication two years ago. The patient was hospitalized on November 6, 2023, around 12:47 pm. The patient has had a recognized instance of left side adhesive capsulitis for 6 months.

A. General Examination

On examination, the patient was aware but required small stimulations from time to time, afebrile, with a pulse of 62 beats per minute, blood pressure of 142/92 mmHg, and respiratory rate of 19 breaths per minute. In general, there was no clubbing, cyanosis, or edema. Cranial nerve evaluation revealed that all cranial nerves were normal, with the exception of the facial nerve, which exhibited minor weakening, and the vestibulocochlear nerve, which had poor balance. The Mini Mental Scale Examination was also completed, and it was normal. Muscle tone on the right side was hypotonic, whereas the left side was normal. The power of the right upper and lower limb was grade one, whereas the left upper and lower limb was grade four. The deep tendon reflex testing for the right side was

3+, suggesting an upper motor neuron injury, whereas the left side was 2+ (normal). The patient was additionally evaluated for adhesive capsulitis utilizing specialized tests such as the shoulder shrugging test, hand to neck test, hand to scapula test, and hand to other scapula test. They were positive in nature.

B. Clinical Findings

The NIHSS score was 13, and an MRI was done on November 10, 2023. A gyral T2/FLAIR hyperintensity is visible in the left posterior parietal area. This lesion has hyperintensity on DWI pictures but no low ADC value. The rest of the cerebral hemispheres are normal, with no clear focal areas of changed signal strength. Sylvain fissures, basal cisterns, and cortical sulci are considered normal. The ventricular system is normal. The basal ganglia, internal capsules, and thalamus are normal. There is no shift in midline structures. Sella and para-sellar structures are typical. In terms of signal qualities, the cerebellum and brain stem are normal. Both orbital and intra-orbital features are typical. Both auditory meati are normal. The MRI findings indicated a sub-acute cortical infarction in the left posterior parietal area. A non-contrast computed tomography (NCCT) was also used. The findings revealed age-related degenerative alterations in the form of large bilateral sulci and gyri, sylvian fissures, basal cisterns, and ventricles. A lacunar infarction was seen in the right capsule-ganglionic area (HU≈15). A lacunar infarction is observed in the left thalamus area (HU≈4). The patient's range of motion was assessed prior to the intervention.

Management:

Short term goals: Maintenance of range of motion, improving muscle strength, improving balance and co-ordination, improving lung patency, mobilization.

Long term goals: Restore the range of motion, restore the muscle strength and restore the muscle tone, gait training, ADL training and functional independence.

Table 1

		Active		Passive	
		Right	**Left**	**Right**	**Left**
Shoulder	**Flexion**	NT	0-150	0-180	0-180
	Extension	NT	100-0	180-0	180-0
	Abduction	NT	0-170	0-180	0-180
	Adduction	NT	160-0	180-0	180-0
	Int. Rotation	NT	0-85	0-90	0-90
	Ext. Rotation	NT	0-80	0-90	0-90

Table 2

		Active		Passive	
		Right	**Left**	**Right**	**Left**
Elbow	**Flexion**	NT	0-135	0-135	0-135
	Extension	NT	135-0	135-0	135-0

Table 3

		Active		Passive	
		Right	**Left**	**Right**	**Left**
HIP	**Flexion**	NT	0-120	0-130	0-130
	Extension	NT	125-0	130-0	130-0
	Abduction	NT	0-45	0-45	0-45
	Adduction	NT	45-0	45-0	45-0
	Int. Rotation	NT	0-40	0-40	0-40
	Ext. Rotation	NT	45-0	45-0	45-0

Table 4

		Active		Passive	
		Right	**Left**	**Right**	**Left**
Knee	**Flexion**	NT	0-128	0-135	0-135
	Extension	NT	135-0	135-0	135-0

Table 5

		Active		Passive	
		Right	**Left**	**Right**	**Left**
Ankle	**Dorsi-Flexion**	NT	0-25	0-25	0-25
	Plantar-Flexion	NT	0-50	0-50	0-50
	Eversion	NT	0-20	0-20	0-20
	Inversion	NT	0-30	0-30	0-30

C. Treatment

1) Treatment Plan for Week 1

On the first day of the session, passive range of motion activities were done for the right upper and lower limbs, followed by active range of motion exercises for the left upper and lower limbs. The therapist stretched the calves, hamstrings, quadriceps, piriformis, triceps, biceps, and wrists. The ankle-toe movement was performed gently and swiftly. [Two sets of ten repetitions]

It was followed by quick icing of the muscles that had been somewhat strained. [19 STROKES, TWO SETS] Many of the methods used in neurological rehabilitation rely on the facilitation and amplification of muscle activation to achieve improved motor control, and many of them also take advantage of neuroplasticity. The Rood Approach is conceptually based on Margaret Rood's Reflex and Hierarchical Model of Motor Control, developed in the 1950s. Roods developed a form of therapy for persons suffering from neuromuscular problems that involved cutaneous stimulation. To achieve optimal muscle stimulation, extero-receptor applicators such as stroking, brushing, ice, warmth, pressure, and vibration take precedence over proprioceptive manoeuvres such as placement, joint compression, joint distraction, and the general use of reflexes, stretch, and resistance. Ice is utilized to elicit a muscle response that combines coolness and pain sensations to accomplish the desired outcome [16].

In addition to icing, muscles were tapped. Icing and tapping both aids to maintain muscle tone.

This procedure was followed for three days throughout the first week. By increasing the amount of repetitions from [10 REPETITION TO 15 REPETITION]

Beginning on day 4 of the first week, increase the number of repetitions in stretching, passive and active range of motion exercises. Regular icing and tapping were also performed. In addition, neural mobilization was performed during the calf and hamstring stretches. The patient was instructed to elevate his head throughout the stretch. If the patient is unable to lift the head off, another therapist aids. The neural mobilization is performed supine. [10 repetitions of both muscles in a single set] This was seen for three days.

2) Treatment Plan for Week 2

The same protocol was used from the first week. However, the repetitions were increased. The patient previously complained of discomfort in his left shoulder, which was a recognized instance of adhesive capsulitis. The therapy for the left shoulder was likewise administered. It included range of

motion exercises, pendulum exercises, half and full bows, stretching, and Ultra-Sound. [5 minutes; 3MHZ - frequency; 1.2W/cm^2 - intensity] Proprioceptive Neuromuscular Rehabilitation of the upper and lower limbs was completed. [5 repetitions, 2 sets, D1 and D2 flexibility and extension]

On the 12th day, the patient was urged to release the grasp from his right hand while holding the therapist's hand. For coordination of hand finger opposition, supination and pronation were included [10 REPETITIONS 2 SETS]. Paraspinal exercises, mostly bridging (passive), were performed in conjunction with knee isometrics, which involved supporting the right knee to avoid falling. [10 repetitions for two sets.]

This protocol was followed for 2 weeks from day 12th – day 21st.

3) Treatment Plan for Week 3

The same treatment was followed starting in week 2. The left upper and lower limbs received modest resistance training. [15 repetitions, 1 set] The number of repetitions was increased for PNF. [10 repetitions, 1 set]

4) Treatment Plan for Week 4

Following the same protocol as in week 3, maximal resistance training for the left upper and lower limbs was completed, as well as minimum resistance for the right upper and lower extremities. Since muscle tone has improved since day one, coordination and balance exercises for the lower limbs have begun. The patient was instructed to sit up from a supine position on the bed, with weight on the afflicted side. Pillows were put on the right side, and the patient was instructed to shift all of his weight to that side; the therapist provided support from behind. This was followed for two weeks. [5 TIMES 1 SET WEEK 4 | 8 TIMES 1 SET WEEK 5]

5) Treatment Plan for Week 5

Following the previous week protocol and providing the treatment for left shoulder which included strengthening exercises and Ultra-Sound [8 MINUTES; 3MHZ – FREQUENCY; 1.5W/cm^2 - INTENSITY]

6) Treatment Plan for Week 6

Strengthening exercises were done on the left upper and lower limbs, while maximal resistance was applied to the right upper and lower extremities. All core muscles were stretched moderately, and grasping was done using a low-resistance gripper. The repetition for neural mobilization was raised from [15 REPETITIONS FOR RIGHT, 25 REPETITIONS FOR LEFT]. The patient was now instructed to undertake a six-to-stand with help. [10 REPETITION] The therapist was seated on a chair in front of the patient, offering support by locking his knees to prevent him from falling.

7) Treatment Plan for Week 7

Following the same protocol from week 6. Since there is a significant increase in muscle tone and a good response in range of motion of both left and right extremities weight training was started. [STARTING FROM 1KG 15 REPETITION 1 SET] followed by sit to stand. This was done in front of mirror.

8) Treatment Plan for Week 8

Gait training was carried out by aiding the patient in walking in a straight line, walking on a parallel board and aided walking in a circle or tandem walk. The patient was made to sit on a Swiss ball for balance training. The patient was advised to extend themselves. [2 Rounds Front Walk; 2 Rounds Reverse Walk; 2 Rounds Parallel Board; 2 Rounds Tandem Walk] Stepping up and down the stairs (4 ROUNDS)

The patient was requested to stand normally on a balancing board [1 MINUTE]; close his eyes [1 MINUTE], then elevate alternate legs at once [2 MINUTE].

9) Treatment Plan for Week 9

Same protocol was followed with slightly increase in repetitions. There was a significant improvement in the range of motion, muscle strength and muscle tone of right and left limb.

By week 10th and 11th the patient was walking on their own with minimal assistance. Balance was improving and repetition was increased focusing more on co-ordination. In week 12th scissor walk [2ROUNDS]; side to side walk [4 ROUNDS] were also performed.

By week 13th and 14th the patient was walking independently without any kind of assistance.

4. Discussion

The patient did not have any cognitive problems, such as dysphagia or slurred speech. The patient's right limb, both upper and lower, was unresponsive to any sensations and had grade 0 muscular power, flaccid muscle tone, inability to execute activities, difficulties with ADLs, and failure to stand and move due to tiredness following stroke.

In this case, several treatment protocols were used, including icing and tapping to help the muscles, Proprioceptive Neuromuscular Facilitation (PNF), neural mobilization, the Bobath technique to re-educate all of the nerves through neuroplasticity, balance and coordination training for both upper and lower limbs, and gait training, which included all types of gait walks.

Traditional therapy includes workouts, resistance exercises, stretching, and exercises, which play an important role in recuperation and avoiding muscular atrophy. The extension is used to preserve or increase joint mobility by altering the expansion of the soft tissue around the joint.

5. Conclusion

According to this case study neuro-rehabilitation is an effective treatment protocol in lacunar stroke and helps to achieve the maximum goal by following a proper protocol. The patient can gain his ability to do ADLs, walk in a normal gait pattern. This case report provided a comprehensive study based on weekly treatment of the patient. Muscle tone and strength were improved through PNF, icing and tapping and Bobath techniques, regular workouts and exercises and balance training outcome measures doing this were improved greatly.

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