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Combining graded motor imagery and traditional physical therapy regimens in postoperative lumbar canal stenosis- A case study

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ABSTRACT

Lumbar Spinal stenosis which is the narrowing of the central canal might be part of a generalized disease process that affects several sections of the canal at different levels, or it can be limited or segmental. Characteristic clinical symptoms include pain, weakness in the lower limbs, and intermittent claudication when walking/standing for a significant amount of time. In determining the diagnosis, the history along with the imaging techniques (X-ray and MRI) can be quite useful. This is a case report of a female complaining of severe chronic low back pain with radiculopathy, diagnosed with lumbar canal stenosis. She was operated with by L3-L4-L5 posterior decompression and L3-L4 discectomy. Along with the conventional approaches, this study included a unique set of technique called as “Monkey see, Monkey do” which is a Graded Motor Imagery training i.e. Cognition training is a process of physical exercises aimed at maintaining or improving one’s cognitive abilities by exercising the brain, which may be hampered by limited physical mobility as a consequence of pain. Rehabilitation showed exceptional improvement in terms of pain and daily activities. This study suggests that the physiotherapy intervention those which are traditional and the advances as cortex reorganization training for lumbar stenosis are effective in management of symptoms. As a consequence, the patients' wellbeing improves.

Keywords: stenosis, rehabilitation, lumbar, physiotherapy

1. INTRODUCTION

Spinal stenosis is the compression of the spinal cord and the spinal nerves which causes narrow canal (Arnoldi et al., 1976). This might be part of a generalized disease process that affects several sections of the canal at different levels, or it can be limited or segmental (Arbit and Pannullo, 2001). Characteristic clinical symptoms include pain, weakness in the lower extremity, and intermittent claudication on excessive locomotion (Amundsen et al., 1995;

Maeda et al., 2018). The most common degree of spinal stenosis is L4 - L5, followed by L5 to S1 and L3 - L4 (Katz and Harris, 2008; Munakomi et al., 2021). It has been defined as "lower extremity pain, which may be with or without the presence of lumbar pain related with reduced disc space for vascular and neural contents" (Mamisch et al., 2012). The pattern of Porter's 2-level stenosis, vascular impairment due to canal stenosis, and nerve root compression due to pathophysiology of degeneration owing to lateral stenosis is responsible for Neurogenic claudication (Genevay and Atlas, 2010).

A critical component of claudication due to neurogenic causes is how it impacts the posture of the patient, with lumbar extension increasing pain and flexion decreasing it, resulting in a distinct "simian stance" found in these individuals. Types of trunk flexion provide pain relief. When inactive, many people are asymptomatic. Extending the back when standing causes discomfort, which are quickly corrected by bending forward 20- 40° at the pelvis, which is a classical presentation (Munakomi et al., 2021). In determining the diagnosis, the history along with the imaging techniques (X-ray and MRI) can be quite useful (Boyd and Villa, 2012). The management can be done conservatively or surgically depending on the severity of the symptoms (Niggemeyer et al., 1997).

Advancements in the scientific studies of brain suggests that brain has a certain pattern for the presentation of physical body parts interconnected with the bundle of neurons which are then stimulated on the part being provoked. People with pain and deficit of it have different representation at S1. So, pain and disability may increase or decrease depending upon the body maps being used or not. To improve the cortical construct, various techniques like use of different sizes and shapes by localizing the tactile area via objects like back of the pen can be used, all these are defined as brain exercises (Louw et al., 2015). Experiments in neurophysiology and imaging studies reveal that humans have a mirror neuron system comparable to that of the apes. In contrast, in monkeys, the mirror neuron system is activated whenever an action has a target object; in humans, it activates while watching activities even in the absence of the target item. In other words, a monkey's system will activate if it observes a hand grasping an apple, while a human's system will also fire if it witnesses a hand movement generating an action, such as a musician's pose (Rizzolatti and Craighero, 2004).

GMI is a three-stage technique designed to aid in the remodeling of the sensory cortex left/right discernment or lateral detection, explicitly motor imagery (EMI), and mirroring treatment. Individuals must properly identify if a picture depicts a person turning left or right with their back exposed in the first step, laterality recognition. The 2nd step, EMI, challenges the patient to visualize executing specific actions without experiencing pain. The third stage is having the person observe the uninjured body part move in a mirror in order to 'mislead' the brain into thinking the injured body part is move painlessly (Sawyer et al., 2018).

GMI training sequencing could be essential in methodically stimulating cortex and helping in remodeling (Moseley, 2005). It is now well acknowledged that tactile inputs with behavioral importance (for eg. braille) can modify primary sensory cortex receptive fields (Bowering et al., 2013).

2. PATIENT'S INFORMATION

This is a case of a 60- year old housewife, right-handed dominance who had a history of fall two and a half years back while doing household chores. After that she started experiencing low back pain which was gradual in onset and progressive by nature. She then undertook some home remedies over time which relieved her pain for a while but did not cure it. She continued doing her activities including prolonged standing, sit- to- stand activities and also helped her husband with farming activities. She then had an increase in the intensity of the pain which hampered her daily activities in the last 1 year from the date of evaluation. For which she took over the counter analgesics. 6 months ago, she started complaining of pain in the lower back region radiating to the left lower limb. At this time, she was unable to bear weight and had difficulty in walking over time. Now, she has come to AVBRH orthopedic department for the same. She was asked to get an x-ray which suggested presence of lumbar canal stenosis at L3-L4 and L4-L5 level with disc lesion. The patient was then surgically managed by L3-L4-L5 posterior decompression and L3-L4 discectomy on 10/11/2021. She was then referred further for physiotherapy treatment.

3. CLINICAL FINDINGS

Consent was obtained from the patient in written format. The patient was informed about the physical examination and the treatment. On examination, patient was conscious, well oriented and hemodynamically stable, with BP-128/78 mm Hg, pulse rate was 84 beats/ min and respiratory rate was 18/min. On pain assessment, she rated her pain as 7/10 on VAS which was gradual in onset and progressive by nature and the site being her low back and left lower leg since 2 and a half years. Movement, basic daily activities and walking were the factors aggravating her pain whereas rest and medications decreased the symptoms.

The patient was examined in supine position. On observation, the patient’s head was centrally placed, hand adducted and forearm in pronation with wrists and fingers slightly flexed. The patient’s legs were slightly abducted and externally rotated, knee in extension and foot plantar flexed. There was sign of inflammation on her lumbar region. On palpation (in sitting position), local temperature of skin was slightly raised. There was tenderness over lower lumbar region of grade 2 and with presence of spasm in Para spinal musculature.

On examination, range of motion of lower limb was assessed. She had reduced ranges in left hip flexion and left knee flexion (table 1 and 2). Lumbar ranges were not testable. Her straight leg raise on the left was positive at 30°. This test produced significant pain into the left lower extremity. She had 3/5 manual muscle test values in the lower extremities for all major muscle groups (table 3 and 4). On neurological examination, all sensations and reflexes were normal. On investigation, X-ray of lumbar spine in A-P view (fig. 1) showed reduced disc space at L3, L4, L5 level with degenerative changes on the day of admission (07/11/2021). On MRI, there is evidence of left paracentral disc protrusion at L3-L4 level indenting on anterior thecal sac causing narrowing of central canal and bilateral neural foramina (left > right) and compressing bilateral transversing nerve roots with posterior annular tear as well as central disc protrusion at L4-L5 indenting on anterior thecal sac.



Figure 1 X-ray of lumbar spine taken on 07/11/2021

Table 1 ROM on POD-1 physiotherapy treatment

	Movement	Left		Right	
		Active	Passive	Active	passive
Hip joint	Flexion	0-60	0-65	0-80	0-100
	Extension	N.T.	NT	0-10	0-15
	Adduction	10-0	30-0	40-0	45-0
	Abduction	0-10	0-30	0-40	0-45
	Internal rotation	NT	0-10	0-20	0-20
	External rotation	NT	0-10	0-20	0-20
Knee joint	Flexion	0-90	0-100	0-135	0-135
	Extension	90-0	100-0	135-0	135-0
Ankle joint	Plantarflexion	0-30	0-40	0-40	0-45
	Dorsiflexion	0-5	0-20	0-20	0-20
	Inversion	0-20	0-35	0-30	0-35
	Eversion	0-10	0-15	0-10	0-15
Lumbar joint	Flexion	N.T.			
	Extension				
	Lateral flexion				

Table 2 ROM assessment on day of completion of treatment

	Movement	Left		Right	
		Active	passive	Active	passive
Hip joint	Flexion	0-100	0-110	0-120	0-125
	Extension	0-20	0-25	0-30	0-30
	Adduction	30-0	35-0	50-0	50-0
	Abduction	0-30	0-35	0-50	0-50
	Internal rotation	0-30	0-40	0-40	0-45
	External rotation	0-30	0-40	0-40	0-45
Knee joint	Flexion	0-110	0-125	0-145	0-150
	Extension	110-0	125-0	145-0	150-0
Ankle joint	Plantarflexion	0-40	0-50	0-45	0-50
	Dorsiflexion	0-20	0-20	0-15	0-20
	Inversion	0-30	0-35	0-30	0-35
	Eversion	0-10	0-15	0-10	0-15
Lumbar joint	Flexion(Tape)	15cm			
	Extension(tape)	11 cm			
	Lateral flexion	0-20	0-30	0-20	0-30

Table 3 MMT on day 1

Movement	Left	Right
Hip flexors	3/5	4/5
Extensors	N.T.	N.T.
Abductors	4/5	4/5
Adductors	4/5	4/5
Internal rotators	-	-
External rotators	-	-
Knee flexors	3/5	4/5
Extensors	4/5	4/5
Ankle plantarflexors	5/5	5/5
Dorsiflexors	5/5	5/5
Lumbar flexion	N.T.	-

Table 4 MMT Post rehab

Movement	Left	Right
Hip flexors	4/5	5/5
Extensors	3/5	3/5
Abductors	5/5	5/5
Adductors	5/5	5/5
Internal rotators	3/5	3/5
External rotators	3/5	3/5
Knee flexors	3/5	4/5
Extensors	4/5	4/5
Ankle plantarflexors	5/5	5/5
Dorsiflexors	5/5	5/5
Lumbar flexion	3/5	

Physiotherapy protocol

Physiotherapy rehabilitation for duration of 3 weeks, 5 days per week, home programmes and follow up. The patient was explained the treatment protocol for her condition and what to expect from the treatment.

Therapeutic intervention

The rehabilitation protocol was modified each week with the inclusion of various exercises.

Phase 1: 0-7 days

Lumbar corset for reduction in the pain and external support was given. The patient was in supine position. She was started with active upper limb strengthening exercises with a 250gm weight bilaterally to gain strength for further treatment. Prehension exercises were taught to the patient. To prevent respiratory complications, pursed lip breathing and Spirometry were begun. Kinaesthetic awareness was used to secure the spine to proceed further for improved stability the position which caused lowest of the pain adapted. Activation of deep segmental muscles like Multifidus and transversus abdominis was done with the help of "Drawing in" manoeuvre before all events so as to know to consciously develop the stability. She was asked to perform ankle pumps actively in both lower limbs. Besides that bilateral heel slides were also taught to the patient. Active straight leg raise (fig. 2) in the available pain-free range was done bilaterally with TA stretches. All exercises were performed for 10 reps in one set. Positioning every 2-hourly was to be done to prevent bed sores and contractures. For that, log-rolling to be done in bed, was taught to the patient. Use of gloves filled with water under both the heels done to avoid pressure sores.



Figure 2 Patient Learning SLR

Phase 2: 8-15 days

Same exercises from first week were continued with the increment in the weight to 500gms for strengthening of upper limb muscles. To habituate the patient to varying forces, dynamic stabilization was carried out via the patient in neutral performing extremities movement along with drawing maneuver. Static Glutes, quads and hamstrings and pelvic bridging (fig. 3) were added. Straight leg rising in available ROM was accompanied by verbal cues to hold the limb in elevation for 5 secs hold. With the back brace on, patient was gradually taken in sitting position over the edge of the bed and trained for balance in same with adaptation to orthostatic hypotension progressed to Dynamic Quads. Initiated walking with back brace on and assistance of walker was taught

and asked not to put too much pressure on back and avoid any circumstances which may cause her fall or imbalances. Myofascial release was done for paraspinal muscles.



Figure 3 Showing patient performing Bilateral Pelvic bridging actively

Graded motor imagery (GMI)

For brain exercises which also improve pain and focus on altering the cortical mapping areas of brain. It included indoctrination done by Graphesthesia in which patient was asked to recognize the numbers from 0-9 or single alphabets which were drawn on her back with pencil's posterior aspect. If wrong estimation, we corrected the patient and repeated the stimulus. The other method inculcated was motor imagery in which she was asked to imagine the movements she wanted to perform after full recovery and make a list of ten such events, printed sheets of activity images were taken out and provided to her. She was asked to close eyes, imagine and share experience. Some activities caused her pain; those were removed and added in the extensive protocol. Both the things were undertaken for 5mins.

Phase 3: 2-3 weeks

Lower limb strengthening with weight cuffs for hip flexors, knee extensors were done in supine. Core strengthening with Upper limb continued for Gait training in sitting, dynamic quads with weight for 5 reps. As she was able to identify the letters written on her back for tactile localization, as her condition flourished numbers were intumesced with increasing the distance between them and using 2 alphabets together. She continued full weight ambulation with brace-on andenjoyed walking in the premises with other patients encouraging her for the same.

Home program

To minimise a recurrence of collapse owing to tiredness and loss of coordination, the patient was taught self-resisting movements, gait conditioning activities and total weight bearing with walking aids.

4. DISCUSSION

Lumbar canal stenosis is the compression of cauda equina in which the lateral or AP diameter of the spine canal is reduced. It can be defined as narrowing of spinal canal, nerve root canal or vertebral foramen. It is mostly co related with aging which causes changes due to pathology of degeneration in the spine. Radiating pain, numbness, tingling are some chief complaints of the patients and some having neurogenic claudication which is recurrence of the signs after ambulation and relieved by rest. The management is done surgically, when needed then followed by physical therapy. It usually includes decompression of the spine (Paine, 1976). GMI has been found to improve pain and impairment in several chronic pain syndromes; these therapies were put in place to address suspected alterations in pain processing. Thieme et al., (2016) found in a recent study that GMI was beneficial in lowering pain and impairment in patients with limb pain, and advised that these techniques should be explored in the management of acute pain post trauma and surgical procedures.

Physiotherapy management focuses on stretching and strengthening of the spinal musculature, preventing any respiratory complications, preventing bed sores and contractures, improving cardio-respiratory health of the patient and thereby enhancing the

quality of life of the patients. During the early post-operative period, tissue is given time for healing by limiting the movement and function to prevent complications post-operatively (Deshmukh, 2021). Modelling is a technique used by physiotherapists to show neuromuscular controlling practices to individuals for optimal continuous learning. It may be useful when first practicing a task since it gives the person with a benchmark for the action as well as visual receptors to create a schema for performance. Furthermore, it may include mirror neurons, which are involved in movement inspection and implementation (Iglar et al., 2021).

Our case report showed a lot of improvement in patient's condition with a lot of improvement in pain which was 2/10 on NPRS for any back movements. Improved SLR and walking with the satisfaction noticed on her face which showed the face validity. There were also tactile changes seen in her after the localisation training which ultimately brings changes in the mapping system of brain usually affected by restrictive movements (Louw et al., 2015). Physical therapy intervention is an effective treatment in an operated case of lumbar spinal stenosis. The ranges of hip flexion, knee flexion and lumbar region were improved with our treatment (table 2). Also, the strength of muscles showed improvement from 3/5 to 4/5 of the affected muscle groups whereas non affected muscles improved from 4/5 to 5/5 (table 4).

5. CONCLUSION

The purpose of this study is to show that the rehabilitation of a case of lumbar stenosis using conventional physiotherapy along with new advances such as cortex reorganization training is effective in the management of the symptoms.

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Author Contributions

All authors mentioned have put their efforts in managing the patient, along with the data collection and preparation of this manuscript.

Informed consent

Written & Oral informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

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Conflicts of interest

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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