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Early Physiotherapy Rehabilitation of Congenital Scoliosis Aftercorrective Surgery- A Case Report

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ABSTRACT

A 15-year-old schoolgirl presented with right shoulder elevation and restricted neck mobility on the same side, which had been noted prior to her referral. Radiological and physical assessments revealed an S-shaped scoliotic curvature located in the proximal dorsal region. The patient subsequently underwent surgical correction of the spinal deformity. Postoperative rehabilitation played a critical role in optimizing therapeutic outcomes. An early, structured rehabilitation protocol was introduced, focusing on targeted exercises aimed at accelerating recovery, fostering functional independence, and enhancing the long-term quality of life in post-surgical scoliosis patients.Early intervention in rehabilitation is increasingly recognized as a cornerstone of effective scoliosis management post-surgery. It not only aids in preventing secondary complications but also contributes significantly to the patient's physical and psychological well-being. A multidisciplinary approach, involving physiotherapists and orthopaedic specialists further enhances the overall success of post-surgical recovery

1. INTRODUCTION

Scoliosis is a three-dimensional spinal deformity characterized by a lateral curvature and axial rotation of the vertebrae, predominantly involving the thoracic and lumbar regions(1). It is often the most visually apparent spinal anomaly, particularly in its advanced stages, with the iconic portrayal of the "hunchback of Notre Dame" exemplifying its severe form. The prevalence of scoliosis within the general population ranges from 0.3% to 15.3% (2). This condition can be classified into postural (non-structural) and structural types. In postural scoliosis, there is an absence of bony deformities, and the curvature is typically secondary to factors such as poor posture, psychological disturbances, nerve root impingement, inflammation, or compensatory mechanisms associated with limb-length discrepancies or lumbar spine contractures.The etiology of scoliosis is multifactorial, encompassing congenital, neuromuscular, syndromic, and idiopathic origins, with idiopathic scoliosis being the most prevalent form encountered in clinical practice. The progression and clinical management of scoliosis are influenced by its underlying etiology and the patient's age at onset, which significantly guide therapeutic strategies(3).

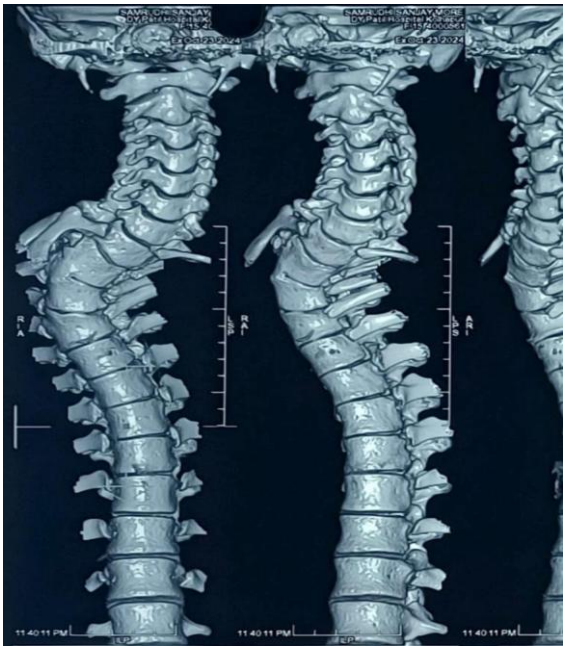
In contrast, structural scoliosis is characterized by intrinsic bony deformities, which may be congenital, acquired, or secondary to severe muscular atrophy, as observed in patients with prolonged quadriplegia. Structural causes include vertebral anomalies such as wedge-shaped vertebrae, hemivertebrae, or failures in vertebral segmentation. In structural scoliosis, spinal flexibility is markedly reduced, and lateral bending of the trunk becomes asymmetrical. This variant of scoliosis has a tendency to progress over time and is typically unresponsive to forward bending maneuvers(3).

Congenital scoliosis, represents one of the most prevalent structural deformities of spine, alongside congenital kyphosis and congenital lordosis. It results from abnormal vertebral development, specifically arising from the defects of vertebral body formation and segmentation. The pathogenesis of congenital scoliosis is believed to be attributed to disruptions occurring

during spinal embryogenesis, particularly between the 5th and 8th weeks of gestation. Consequently, it is frequently associated with a range of concomitant malformations, congenital heart disease, spinal cord dysraphismsand renal abnormalities.

A comprehensive understanding of the deformity's natural history and available treatment modalities is essential for effective clinical management. Advanced diagnostic imaging modalities, such as three-dimensional computed tomography (CT) and magnetic resonance imaging (MRI), are indispensable for the detailed evaluation of the structural deformity. Therapeutic management typically involves either vigilant observation or, in cases where the curvature progresses by more than 10 degrees annually, surgical intervention. Surgical options are broadly categorized into two approaches: (1) prophylactic procedures, such as hemiepiphysiodesis or in situ spinal fusion, aimed at halting further curve progression or facilitating gradual correction, and (2) corrective surgical interventions, including spinal fusion with or without vertebral resection, designed to realign the spine and stabilize the deformity

Figure: Showing scoliotic curve with hemivertebrae at D3 level



The primary objective of scoliosis surgery is to achieve optimal vertebral alignment through a safe procedure, restore balance to the back and pelvis, and ensure the long-term preservation of the correction. During scoliosis reconstruction surgery, pedicle screws and rods are typically inserted into the thoracic and lumbar vertebrae to correct the deformity and facilitate fusion [(2)]. Surgical management of congenital scoliosis is influenced by a variety of factors, including the nature of the associated congenital anomalies, the degree of spinal deformity, and the patient's age. Numerous surgical interventions have been described, including in situ spinal fusion, which may involve posterior spinal fusion (PSF) alone or a combination of both posterior and anterior spinal fusion. Additional surgical approaches include convex epiphysiodesis, hemiepiphysiodesis, expansion thoracoplasty using vertical expandable prosthetic titanium rib implants (VEPTR), and the use of growth-modulating devices such as growing rods.Often, a combination of these techniques is employed in a single patient to address the deformity comprehensively. Due to the intricate nature of surgical decision-making in congenital scoliosis, these procedures carry a heightened risk of both neurological and non-neurological complications post operatively, for which the author feels physiotherapy play a great role for gaining patients functional independence.

Rehabilitation program following spinal deformity correction is to restore the patient's full functional capacity as swiftly as possible, without compromising the integrity of the surgical procedure. Postoperative rehabilitation principles should be implemented by the rehabilitation team to assist the patient in returning to normal daily activities. This involves preventing secondary deformities, such as contractures resulting from reduced mobility, facilitating adaptation to daily living activities when the patient has limited mobility or is wearing an orthosis, understanding the underlying pathological condition and its impact on function, and gradually reconditioning the patient once the spine has stabilized. Rehabilitation programs typically consist of exercises that avoid placing undue stress on the healing areas [(2)].

CASE DISCRIPTION

A 15-year-old female presented in OPD with the complaint of elevation of right shoulder and restrictedright side neck movements.Accordingly, the patients mother noticed that there was an elevation of the right shoulder and difficulty in right side neck movementsin the last 1 year and the lateral curvature of the spine went unnoticed till last year.For which the patient was referred to Dr. D.Y. PatilHospital, Kolhapur, here the patient underwent all the necessary investigations likeX-ray, MRI, CTscan, CBC, LFT, RFT, HCV and HbsAg on 1st January 2025. From physical examination and investigations done, it was observed that she hadelevation of right shoulder and cervico-thoracic region muscle spasm, decrease of chest expansion with decrease of trunk flexibilityas well. With respect to the above investigationspatient was diagnosed with congenital scoliosisand slight S shaped curve of upper dorsal spine convexity C7-D7.D2-D3 fusion i.e. D3 hemivertebraeand lateral wedging of D5 vertebrae was observed. The Cobb's angle was measureddegrees. Based on the examinations, investigations and the severity of scoliosis, considering patient's end growth period, surgery was planned and done on 4th of January, 2025.

Figure: Showing scoliotic curve in standing and forward bending.

OPERATIVE PROCEDURE

The patient underwent a correction of a scoliotic deformity with fixation from C7 to D9 on January 4, 2025. Positioned prone under general anaesthesia, the patient was prepped with appropriate antiseptic measures for painting and draping. Skin markings were made from C7 to D9 using an 18-gauge needle, and confirmed with the C-arm. A vertical midline incision was made from C6 to D9, followed by the incision of subcutaneous tissues and fascia. Subperiosteal elevation and dissection of the paraspinal muscles were performed from C6 to D9. The posterior segment was visualized, and the walls of the pedicles were assessed with ball-tip probes. Polyaxial pedicle screws of various sizes (5.5 x 30mm, 4.5 x 25mm, 3.5 x 20mm, and 3.5 x 22mm) were inserted from C7 to D9, except at the D3 level. Tapered rods measuring 3.5-5.5mm x 500mm were placed, starting on the left side and then on the right side. Decompression was carried out at the D3 level, where the hemivertebrae was present, and rods were inserted. Spinal correction was performed following neuromonitoring guidelines with right-side compression and left-side distraction. A final neuromonitoring test was conducted post-procedure, showing satisfactory results. The site was thoroughly irrigated, and bone graft was placed, which was taken from the spinous processes of the vertebral bodies. A drain was placed, and closure was performed in layers with antiseptic precautions, followed by dressing. The patient was then extubated and transferred to the recovery room.

Figure: Post- operative X-Ray

POST-OPERATIVE SCOLIOSIS ASSESSMENT:

A 15-year-old female having upper dorsal spine scoliosis, con-vexing towards the right side, fusion of D2 and D3 vertebral bodies with no cord compression, residing in Kagal, weighing 26kg and height exactly 142cmwith BMI-12.9kg/m^2(underweight) was admitted in Dr. D.Y.Patil Hospital, Kolhapur on 1st January, 2025 for the corrective surgery of scoliosis.Patient was planned for scoliosis correction by Hemi excision of D3 and 3 levels above and below fixation.Patient is ectomorphic in built and poorly nourished. Thedate of surgery was 4th of January 2025 and post-operative examination was done on 5th of January, 2025.

Patient had no significant complaints of painbefore surgery. Post operatively on examination the patient complained of pain on neck, back, chest, around the area of surgery and generalized weakness.

Age of onset:Since birth

Pain History:

Onset:Sudden

Precipitating factor: On lateral rotation of neck to both sides and side lying.

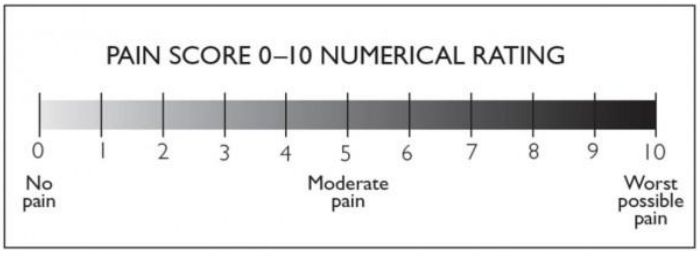
Quality of pain: dull aching

Relieving Factor:Analgesics and positioning

Site: cervical and thoracic region

Temporal Variation: Nothing significant

Numerical pain rating scale:



On activity: 9/10 At rest: 7/10

Drug history:Inj. Cefuroxime- 50mg (IV)

Inj. Pantoprazole- 20mg (IV)

Inj. Tramadol-50mg (IV)

Inj. Paracetamol- 500mg (IV)

On observation:

High riding scapula on the right side

Direction of growth of curve: Right side convexity and left side concavity

Skin: No trophic changes or signs of infection noticed.

Figure: Scoliotic curve in standing and forward bending.

On palpation:

Tenderness: present over the operated site.

Grade 2: Patient winces on palpating the operated site

Site: Cervical and thoracic region of back

Tightness: Hamstring tightness was present.

On examination:

Assessment of pubertal development:

Degree of Cobb's angle: 44 degrees

Degree of correction: 14 degrees

Tone: Not affected

Range of motion:

Sr no	Joints	Flexion	Extension	Abduction	Adduction	Medial Rotation	Lateral Rotation
1.	Shoulder	Left:140^0 Right: 140^0	Left:35^0 Right:35^0	Left: 130^0 Right: 130^0	Left: 130-0^0 Right: 130-0^0	Left:93^0 Right: 95^0	Left: 28^0 Right: 28^0
2.	Elbow	Left: 136^0 Right: 136^0	Left: 136-0^0 Right: 136-0^0	—	—	—	—

Sr no.	Joints	Flexion	Extension	Ulnar deviation	Radial deviation	Pronation	Supination
3.	Wrist	Right: 85^0 Left: 85^0	Right: 78^0 Left: 80^0	Right: 25^0 Left: 25^0	Right: 18^0 Left: 18^0	Right: 90^0 Left: 90^0	Right:90^0 Left: 90^0
4.	Cervical Region	Flexion: 34	Extension: 50	Lateral Flexion Right: 25	Lateral Flexion Left: 20	Lateral Rotation Right: 45	Lateral Rotation Left: 45

Manual Muscle Testing:

(According to MMRC Scale)

Sr no.	Muscles and joints	Right	Left
1.	Cervical region	Lateral flexion: 3/5 Lateral rotation:3/5 Flexion:3/5 (no specific side) Extension:3/5(no specific side)	Lateral flexion:3/5 Lateral rotation:3/5
2.	Shoulder joint	Flexion: 4/5 Extension: 4/5 Abduction: 4/5 Adduction: 4/5	Flexion: 4/5 Extension: 4/5 Abduction: 4/5 Adduction: 4/5

		External rotation: 4/5 Internal rotation: 4/5	External rotation: 4/5 Internal rotation: 4/5
3.	Elbow joint& radioulnar joint	Flexion: 4/5 Extension: 4/5 Pronation: 4/5 Supination: 4/5	Flexion: 4/5 Extension: 4/5 Pronation: 4/5 Supination: 4/5
4.	Wrist joint	Flexion: 4/5 Extension: 4/5 Radial deviation: 4/5 Ulnar deviation: 4/5	Flexion: 4/5 Extension: 4/5 Radial deviation: 4/5 Ulnar deviation: 4/5
5.	Metacarpophalangeal, PIP & DIP Joints	Flexion: 4/5 Extension: 4/5 Abduction and adduction: 4/5	Flexion: 4/5 Extension: 4/5 Abduction and adduction: 4/5

Limb length:

Squaring of pelvis- 13.2inch

True:

Right side	Left side
33 inches	33 inches

Apparent limb length –

Right side	Left side
34.8 inches	34.8 inches

Foot shape: No abnormality was noted

Posture:

Anterior View: Patient in standing facing forward with head and neckslightly tilted to right side.Right shoulder slightly elevated, pelvic in neutral position, hip slight externally rotated, knee and ankle in neutral position.

Lateral View: The patient exhibits forward head posture, with the head tilted approximately 6 degrees anterior to the shoulders.The is a slight elevation of shoulder, the pelvis is in neutral position, hip slightly externally rotated, knee and ankle in neutral position.

Posterior View: The patient is standing with the head and neck slightly tilted to the right, and the ears are aligned. The right shoulder is elevated, with prominence of the right scapula compared to the left, pelvis in neutral position, while the hips in slight external rotation, knees, and ankles are in a neutral position.

Gait:

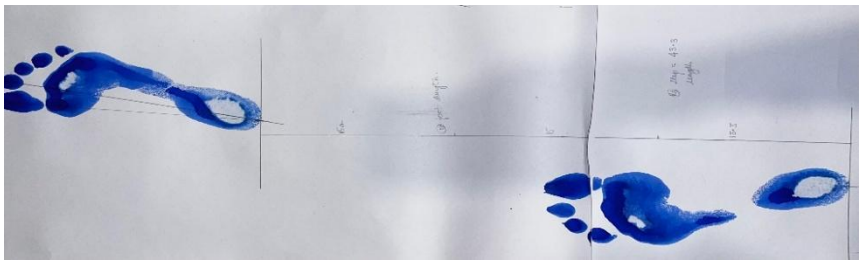
Stride length-89.2cm

Step length-(Right)- 43.3cm

(Left)- 45.4cm

Step Width- 4cm

Toe out angle (Right& Left)- 7^0



Sensation: Intact

Reflexes:Grade 2+ (Active response)

Coordination: intact

Bowel and bladder: regular and Independent

Heel to toe test:Positive

Crossed leg sitting:Positive (no abnormality was noticed)

IMAGING EVALUATION

Pre-operative radiological findings:

X-Ray:

Figure: Pre-operative X-ray

Plain radiograph of the whole spine (antero-posterior view) shows:

A scoliotic curve of the proximal dorsal spine, convex towards the right side, with fusion of the D2 and D3 vertebral bodies. The apex of the curve is at the C7 level, and D7 is the terminal vertebra of the scoliotic curve.

MRI:

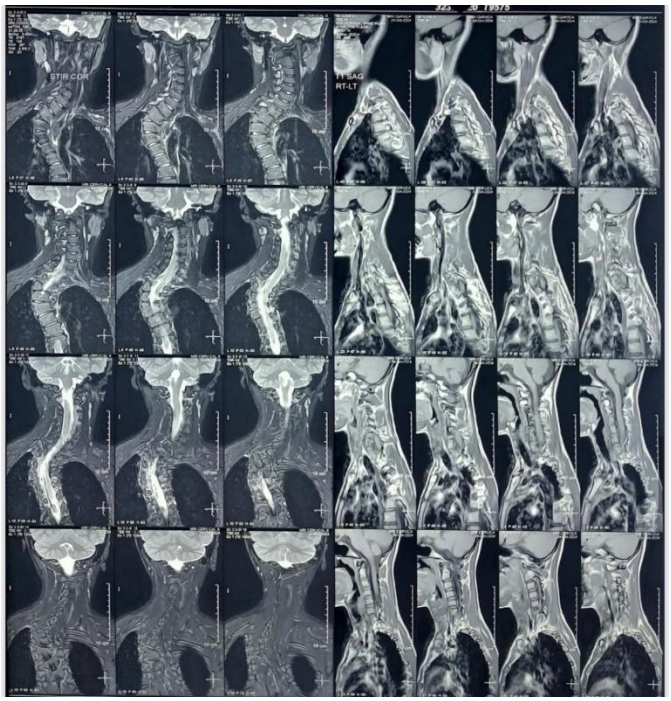


Figure: Showing MRI scans of patient

Multiplanarmultiecho MRI of the cervical and dorsal spine was performed with whole spine screening.

Findings:

Moderate scoliosis of the dorsal spine is noted with convexity towards right side.

There is fusion of D2 and D3 vertebral bodies and their posterior elements.

No significant posterior disc bulge/ cord compression.

CT SCAN:

Figure: Showing CT scanof spine

Plain CT scan of cervical spine was done by taking 5mm thin axial sections parallel to vertebral bodies and discs.

Findings:

Scoliosis of upper dorsal spine

D3hemivertebrae noted.

D2, D3 block vertebrae

Lateral wedging of D5 vertebrae

Post-operative radiological findings:

X-ray findings:

Figure: Showing post operative X-ray of scoliosis correction.

Plain radiograph of the thoracic spine (antero-posterior view) shows:

Scoliosis correction with spinal fixation from the C7 to D9 vertebral levels.

Hemi-excision at the D3 vertebral level, with fixation involving three levels above and below.

Polyaxial pedicle screws of various sizes (5.5 mm x 30 mm, 4.5 mm x 20 mm, 3.5 mm x 20 mm, and 3.5 mm x 22 mm) have been inserted from C7 to D9.

Decompression performed at the D3 vertebral level.

REHABILITATION PROTOCOL

Pre-operative period:

PHASE 1:

Goals: To provide comprehensive education to both the patient and their family regarding the severity of the condition, the patient's current medical status, and the necessary precautions and preventive measures to be adhered to by the family members.

Additionally, this phase will offer an overview of potential postoperative complications and underscore the critical importance of adhering to a physiotherapy rehabilitation protocol. This protocol incorporates a variety of techniques and instruments, such as the incentive spirometer, designed to enhance the patient's respiratory function. Various exercise protocol for musculoskeletal system and neurological system in order to gain muscle power, balance and coordination and equilibrium are focused, thereby promoting the swift attainment of functional independence in activities of daily living.

Moreover, nutrition serves as a cornerstone for optimizing bodily performance. A thorough counselling session was conducted to emphasize the pivotal role of nutrition in boosting the patient's recovery, ensuring enhanced performance during the rehabilitation phase.

PHASE 2:

Post-operative active phase (Early discharge phase)

Techniques and exercises (1ST WEEK)

From post-operative day 2- 2 weeks

Positioning of the patient. Log rolling and segmental rolling exercise on each side.

10 reps each side.

Breathing exercises: Pursed lip breathing, Diaphragmatic breathing, Segmental breathing.

Thoracic expansion breathing, Huffing and coughing technique, Incentive Spirometer

10 reps of each breathing exercise.

General mobility exercise for Bilateral Upper limb: Shoulder, elbow, wrist and finger movements.

10 reps of each movement.

General mobility exercise for bilateral Lower limb: Pelvic rolling and bridging, Hip, knee and ankle mobility exercises. (i.e. straight leg raises, ankle & toe movements).

10 reps of each movement. Straight leg raises included a hold for 5-10 seconds.

Isometric exercises: Upper limb isometrics, Lower limb including static Quadriceps, static Hamstrings, VMO strengthening and Ankle isometrics.

10 reps with 10 second hold of each exercise.

Techniques and exercises: (2nd WEEK)

Exercises same as 1st week were followed with progression including:

Positioning and bed mobility exercises: Supine to side lying, Side lying to sit, sit to stand (with support of walker), Bed side sitting, Pelvic bridging and pelvic rolling exercises with 5-10 sec hold. **10reps x 3 sets of each exercise**

Isokinetic exercises with half kg weight: Bicep curls, Wrist flexion & extension, Straight leg raises, Knee flexion & extension **10reps X 3 Sets of each exercise.**

Postural correction exercises: Stretching with 30 sec hold, Myofascial release technique for pectoral region, Neck movements, Neck Isometrics, Shoulder elevation, depression, protraction and retraction movements, Shoulder isometrics, Chin tucks **10reps x 3 sets**

Coordination exercises: Foot tapping exercises, Heel to shin, drawing a circle with foot, B/L Upper Limb Reach outs, Side leg raising exercises, Pelvic tilts, Toe taps.

10reps x 3 sets of each exercise

Balance and equilibrium exercises: Split Stance arm reach, walking on straight line, Tandem standing with eyes open and

closed, Single leg balance.

1oreps x 3 sets of each exercise

Gait training: Spot marching, Stepper exercises, seated marching, Knee extension exercises, Forward and backward stepping, Side stepping, Single leg stance, walking on footprints, Heel raises, Toe raises, Walking over obstacles, Forward and backward walking, Side to side walking

10reps x 3 sets each exercise.

PHASE 3:

Post discharge phase

Home Protocol: 2 week- 2months.

First 15days protocol

General mobility exercises: B/L Upper extremity mobility exercises, B/L Lower extremity, mobility exercises, Straight leg raises with 15 sec hold, Side leg raises with 15 sec hold.

10reps x 3 sets of each exercise

Breathing Exercises: Diaphragmatic breathing exercises, Pursed lip breathing exercises

Thoracic expansion.

10reps x 3 sets of each exercise.

Postural correction exercises: Self-stretching exercises for B/L Upper limb x 15 second hold

Stretching for B/L Lower limb x 15 second hold, Stretching of neck muscles x 30 second hold

Neck Movements, Neck isometrics, Shoulder mobility exercises, Scapular mobility exercises

Shoulder isometrics, Cervical pillow advised, Passive Trunk rotation stretching exercises

10reps x 3 sets of each exercise.

Strengthening exercises: Bird-dog position, wall squats.

10 reps with 10 sec hold of each exercise.

15-30 Days protocol

General mobility exercises: B/L Upper extremity mobility exercises, B/L Lower extremity, mobility exercises, Straight leg raises with 30 sec hold, Side leg raises with 30 sec hold, forward bending exercises.

10reps x 3 sets of each exercise

Breathing Exercises: Diaphragmatic breathing exercises, Pursed lip breathing exercises, Thoracic expansion.

10reps x 4 sets of each exercise

Postural correction exercises: Self-stretching exercises for B/L Upper limb x 30 second hold

Stretching for B/L Lower limb x 30 second hold, Stretching of neck muscles x 30 second hold

Neck Movements, Neck isometrics, Shoulder mobility exercises, Scapular mobility exercises

Shoulder isometrics, Cervical pillow advised, Passive Trunk rotation stretching exercises

10reps x 4 sets of each exercise

Strengthening exercises: Core strengthening exercises: Pelvic tilts, deep breathing with abdominal bracing, pelvic bridging, Bird-dog position, Wall squats, Half squats.

15 reps with 15 sec hold of each exercise

Gait training exercises: Spot marching, Stepper exercises, seated marching, Knee extension exercises, Forward and backward stepping, Side stepping, Single leg stance, walking on footprints, Heel raises, Toe raises, Walking over obstacles, Forward and backward walking, Side to side walking.

15reps x 3 sets of each exercise

Endurance Training: Cardiovascular endurance: walking and Static cycling with low resistance.

Walking Static cycling for 10 minutes.

Balance and coordination exercises: Single leg stance (supported), tandem walking, weight shifts in standing, balancing on pillow with eyes opened.

10reps x 2 sets of each exercise

2ND MONTH PROTOCOL

General mobility exercises: B/L Upper extremity mobility exercises, B/L Lower extremity mobility exercises, Straight leg raises with 30 sec hold, Side leg raises with 30 sec hold, Forward bending exercises.

10reps x 3 sets of each exercise.

Breathing Exercises: Diaphragmatic breathing exercises, Pursed lip breathing exercises

Thoracic expansion. **10reps x 4 sets of each exercise.**

Postural correction exercises: Self-stretching exercises for B/L Upper limb x 30 second hold

Stretching for B/L Lower limb x 30 second hold, Stretching of neck muscles x 30 second hold

Neck Movements, Neck isometrics, Shoulder mobility exercises, Scapular mobility exercises

Shoulder isometrics, Cervical pillow advised, Passive Trunk rotation stretching exercises

10reps x 4 sets of each exercise.

Strengthening exercises: Core strengthening exercises: Pelvic tilts, deep breathing with abdominal bracing, pelvic bridging, Bird-dog position, wall squats Half squats, Dead bug, Bridges Superman holds, Step ups Theraband exercises for hip mobility and Russian twists.

15 reps with 15 sec hold of each exercise.

Balance and coordination exercises: Single leg stance (supported), Tandem walking, Weight shifts in standing, Balancing on pillow with eyes opened.

10reps x 2 sets of each exercise.

Gait training exercises: Spot marching, Stepper exercises, seated marching, Knee extension exercises, Forward and backward stepping, Side stepping, Single leg stance, Walking on footprints, Heel raises, Toe raises, Walking over obstacles, Forward and backward walking, Side to side walking.

15reps x 3 sets of each exercise.

Endurance Training: Cardiovascular endurance: walking and Static cycling with low resistance.

Walking Static cycling for 10 minutes

2. DISCUSSION

Physiotherapy stands as an indispensable pillar in the management of scoliosis, encompassing both its conservative treatment and post-surgical rehabilitation. Its multifaceted role extends beyond mere symptom alleviation, serving as a cornerstone for enhancing functional outcomes, mitigating progressive deformity, and fostering an optimal quality of life for individuals affected by this spinal condition. This holistic approach not only addresses the structural aspects of scoliosis but also emphasizes the importance of improving physical function, posture, and overall well-being.

Moreover, early physiotherapy fosters the development of proprioceptive awareness and body mechanics education, empowering patients to adopt postural strategies that minimize asymmetrical loading of the spine. This proactive approach not only mitigates the risk of curve progression but also enhances the patient's overall physical fitness and psychological well-being. Following surgical intervention for scoliosis, such as spinal fusion or corrective osteotomies, physiotherapy assumes a critical role in facilitating optimal recovery and functional restoration. Post-operative physiotherapy focuses on several key objectives: minimizing complications, enhancing spinal mobility within safe limits, restoring strength and endurance, and promoting the reintegration of the patient into daily activities.

The interaction of bone formation with corrective scoliosis surgery is a dynamic process involving the biological integration of bone with surgical implants. Successful spinal correction relies on the phenomenon of osseointegration, where new bone growth establishes a stable, functional bond with the implant surface. This integration is facilitated by the mechanical stability provided by the implant, which promotes osteogenic activity, while the implant’s surface properties influence the rate and quality of bone formation. The correlation between bone and implant is crucial, as robust osseointegration ensures the long-term durability of the correction, minimizes implant-related complications, and supports the mechanical demands placed on the spine post-surgery[27, 28, 29, 30].

In our research, the physiotherapy protocol administered to patients' post-scoliosis corrective surgery was meticulously tailored to align with the progression of bone healing. This individualized approach ensured that therapeutic interventions corresponded with specific stages of bone formation, thereby optimizing recovery outcomes. Bone healing and osseointegration typically commence within the first few weeks' post-surgery, with significant advancements observed between 6 to 12 weeks.

Our protocol commenced with gentle general mobility exercises and breathing techniques during the first week, focusing on minimizing pain and optimising the functional capacity of respiration with promoting early mobility. As bone healing progressed, more dynamic exercises were introduced to enhance muscle strength and joint stability. This phased approach ensured that physiotherapeutic interventions were congruent with the patient's healing trajectory, promoting effective recovery while safeguarding surgical outcomes.

Early rehabilitative exercises for post-operative scoliosis patients have proven to be highly effective in enhancing recovery outcomes, promoting functional mobility, and reducing the risk of complications such as muscle atrophy and joint stiffness. However, the necessity of immobilization remains a critical component, particularly in the context of spinal arthrodesis, to ensure optimal bone healing and implant stability. Following the acute phase, the patient was advised to continue wearing a spinal brace for a minimum of six months, extending up to one year if needed. This brace serves to provide additional support during the transitional period of bone remodelling and to reinforce the structural integrity of the spine while gradually reintroducing more dynamic activities as the healing process progresses. This immobilization strategy is essential during the initial healing phase to protect the surgical site and facilitate successful fusion[24, 25].

All exercises outlined (General mobility exercises, strengthening exercises, balance and coordination exercises as well as all the neuromuscular facilitatory techniques) in the hospital-to-home protocol for the patient with scoliosis were thoroughly followed during the transition to the Milwaukee brace. The prescribed regimen was carefully adhered to, ensuring proper implementation at every stage. This approach supported the effective use of the brace and facilitated the patients' recovery process [15,16,17].

In conclusion, the structured physiotherapy regimen, aligned with the stages of bone healing and supported by appropriate immobilization strategies, significantly contributes to the recovery and long-term well-being of post-operative scoliosis patients. This comprehensive approach not only enhances functional outcomes but also promotes a higher quality of life, as evidenced by follow-up assessments.

3. CONCLUSION

Post-operative physiotherapy is essential for scoliosis patients to restore function, prevent complications, and enhance quality of life. Key components include mobility exercises to improve joint flexibility, reduce stiffness, and promote early mobilization, which helps prevent complications like muscle atrophy. Breathing exercises are particularly important as scoliosis can impact respiratory function, and these exercises enhance lung capacity and oxygenation, supporting overall recovery. Stretching further complements this by relieving muscle tightness, maintaining range of motion, and addressing postural imbalances.

In addition to these, core stability and strengthening exercises play a critical role in supporting spinal alignment and reducing the risk of compensatory movements that could strain the surgical site. Balance training improves neuromuscular control, enhances coordination, and reduces the risk of falls, while endurance training helps rebuild cardiovascular fitness and physical stamina. Together, these physiotherapy modalities not only accelerate recovery but also ensure long-term functional independence and improved quality of life for post-operative scoliosis patients.

In conclusion, the early physiotherapy approach significantly contributed to the recovery of post-operative scoliosis patients. The quality of life was assessed through standardized "Quality of life scale" during follow-up, revealing notable improvements in physical function, pain reduction, and overall well-being. These findings underscore the effectiveness of early rehabilitation in enhancing recovery outcomes, promoting functional independence, and improving the long-term quality of life for scoliosis patients after surgery

REFERENCES

[1] Goldberg CJ, Moore DP, Fogarty EE, Dowling FE. Scoliosis: a review. Pediatric surgery international. 2008 Feb;24:129-44.

[2] Ekawana, P., &Poerwandari, D. (2022). Rehabilitation of adolescent idiopathic scoliosis after corrective surgery: A case report. International Journal of Health Sciences, 6(S8), 24 29. https://doi.org/10.53730/ijhs.v6nS8.11499

[3] Goldstein LA, Waugh TR. Classification and terminology of scoliosis. Clinical Orthopaedics and Related Research (1976-2007). 1973 Jun 1;93:10-22.

[4] Arlet V, Th. Odent, Aebi M. Congenital scoliosis. European Spine Journal 2003 10;12(5):456-63.

[5] Chiu CK, Tan RL, AbdGani SM, Chong JS, Chung WH, Chan CY, Kwan MK. Feasibility of Single-Stage Posterior Passive Correction and Fusion Surgery for Congenital Scoliosis in Adolescent Patients Who Have Attained Skeletal Maturity. Asian Spine Journal. 2021 May 7;16(3):315.

[6] Chu EC. Neuromuscular scoliosis in the presence of spina bifida occulta and a transitional lumbosacral vertebra: A case report. Radiology case reports. 2022 Sep 1;17(9):3260-5.

[7] Leichtle CI, Kumpf M, Gass M, Schmidt E, Niemeyer T. Surgical correction of scoliosis in children with congenital heart failure (Fontan circulation): case report and literature review. European Spine Journal. 2008 Sep;17:312-7.

[8] Perdriolle R, Vidal J. Morphology of scoliosis: three-dimensional evolution. Orthopedics. 1987 Jun;10(6):909-15. doi: 10.3928/0147-7447-19870601-10. PMID: 3615285.

[9] Hedequist D, Emans J. Congenital scoliosis: a review and update. J PediatrOrthop. 2007 Jan-Feb;27(1):106-16. doi: 10.1097/BPO.0b013e31802b4993. PMID: 17195809

[10] Damsin, Jean-Paul*; Cazeau, Cyrille†; Carlioz, Henri‡. Scoliosis and Fused Ribs: A Case Report. Spine 22(9):p 1030-1032, May 1, 1997.

[11] Shi W, Giuste FO, Zhu Y, Tamo BJ, Nnamdi MC, Hornback A, Carpenter AM, Hilton C, Iwinski HJ, Wattenbarger JM, Wang MD. Predicting pediatric patient rehabilitation outcomes after spinal deformity surgery with artificial intelligence. Commun Med (Lond). 2025 Jan 2;5(1):1. doi: 10.1038/s43856-024-00726-1. PMID: 39747461; PMCID: PMC11697361.

[12] Gavriliu S, Vlad C, Georgescu I, Burnei G. Diastematomyelia in congenital scoliosis: a report of two cases. Eur Spine J. 2014 May;23 Suppl 2:262-6. doi: 10.1007/s00586-014-3218-x. Epub 2014 Feb 18. PMID: 24535633.

[13] Hensinger, Robert N. MD. Congenital Scoliosis: Etiology and Associations. Spine 34(17):p 1745-1750, August 1, 2009. | DOI: 10.1097/BRS.0b013e3181abf69e

[14] Huang, Jing-Hui MD; Yang, Wei-Zhou MD; Shen, Chao MD; Chang, Michael S. MD; Li, Huan MD; Luo, Zhuo-Jing MD; Tao, Hui-Ren MD. Surgical Treatment of Congenital Scoliosis Associated With Tethered Cord by Thoracic Spine-shortening Osteotomy Without Cord Detethering. Spine 40(20):p E1103-E1109, October 15, 2015. | DOI: 10.1097/BRS.0000000000001035

[15] Lara TM. Rehabilitation Treatment Protocol in Scoliosis. EC Orthopaedics. 2021;12:86-97.

[16] Weiss H, Moramarco MM, Borysov M, Shu YN, Sang GL, Nan X, et al. Postural Rehabilitation for Adolescent Idiopathic Scoliosis during Growth. Asian Spine Journal 2016 06;10(3):570-581.

[17] .Borysov M, Borysov A. Scoliosis short-term rehabilitation (SSTR) according to ‚Best Practice' standards-are the results repeatable? Scoliosis 2012;7:1.

[18] Ryan Neufeld. Improving scoliosis rehabilitation. United States -- Texas: The University of Texas at Arlington; 2014.

[19] Alamrani S, Rushton A, Gardner A, Falla D, Heneghan NR. Outcome measures evaluating physical functioning and their measurement properties in adolescent idiopathic scoliosis: a protocol for a systematic review. BMJ Open 2020;10(4).

[20] Kaustubh A, Syed I, Samarth M, Gagandeep Y, Venkata SP, Sitanshu B, et al. Is detethering necessary before deformity correction in congenital scoliosis associated with tethered cord syndrome: a meta-analysis of current evidence. European Spine Journal 2021 03;30(3):599-611.

[21] Tsirikos AI, McMaster MJ. CONGENITAL ANOMALIES OF THE RIBS AND CHEST WALL ASSOCIATED WITH CONGENITAL DEFORMITIES OF THE SPINE. Journal of Bone and Joint Surgery 2005 11;87(11):2523-36.

[22] Bao B, Su Q, Hai Y, Yin P, Zhang Y, Zhu S, et al. Posterior thoracolumbar hemivertebra resection and short-segment fusion in congenital scoliosis: surgical outcomes and complications with more than 5-year follow-up. BMC Surgery 2021;21:1-10.

[23] Bazancir Z, Talu B, Korkmaz MF. Postoperative rehabilitation versus early mobilization following scoliosis surgery: A single-blind randomized clinical trial. J Orthop Sci. 2023 Mar;28(2):308-314. doi: 10.1016/j.jos.2021.11.017. Epub 2021 Dec 16. PMID: 34922807.

[24] ÖzyemişciTaşkıran Ö. Rehabilitation in adult spinal deformity. Turk J Phys Med Rehabil. 2020 Mar 16;66(3):231-243. doi: 10.5606/tftrd.2020.6225. PMID: 33089079; PMCID: PMC7557622.

[25] Bazancir Z, Talu B, Korkmaz MF. Postoperative rehabilitation versus early mobilization following scoliosis surgery: A single-blind randomized clinical trial. J Orthop Sci. 2023 Mar;28(2):308-314. doi: 10.1016/j.jos.2021.11.017. Epub 2021 Dec 16. PMID: 34922807.

[26] Gao C, Chen BP, Sullivan MB, Hui J, Ouellet JA, Henderson JE, Saran N. Micro CT analysis of spine architecture in a mouse model of scoliosis. Frontiers in Endocrinology. 2015 Mar 19;6:38.

[27] Joo P, Maqsoodi N, Sulovari A, Omar A, Sanders J, Rubery P, Menga E, Mesfin A. Ultralong follow-up of spinal fusion for adolescent idiopathic scoliosis: Harrington instrumentation vs uninstrumented fusion. International Journal of Spine Surgery. 2022 Dec 1;16(6):977-82.

[28] Kia C, Antonacci CL, Wellington I, Makanji HS, Esmende SM. Spinal implant osseointegration and the role of 3D printing: an analysis and review of the literature. Bioengineering. 2022 Mar 6;9(3):108.

[29] Karimi MT, Kavyani M, Mehrvar A. Osseointegration: A new approach to improve functional performance of prostheses–a systematic review of the literature. Current Orthopaedic Practice. 2024 Nov 1;35(6):229-36.

[30] Shum LC, Hollenberg AM, Baldwin AL, Kalicharan BH, Maqsoodi N, Rubery PT, Mesfin A, Eliseev RA. Role of oxidative metabolism in osseointegration during spinal fusion. PLoS One. 2020 Nov 9;15(11):e0241998.

[31] Williamson A, Hoggart B. Pain: a review of three commonly used pain rating scales. J ClinNurs. 2005 Aug;14(7):798–804. doi: 10.1111/j.1365-2702.2005.01121.x