EFFECT OF PREHABILITATION ON POST-OPERATIVE OUTCOMES IN A CHILD WITH BASILAR INVAGINATION – An ICF BASED CASE REPORT

Akshara Kadali[1], Dr. V. Srikumari[2], Dr. G. Kameswari[3]

[1]MPT Neurology, Physiotherapy, Sri Venkateswara Institute of Medical Sciences, COP

[2]MPT(Neuro), PhD, Associate professor, Physiotherapy, Sri Venkateswara Institute of Medical Sciences, COP

[3]MPT(Neuro), PhD, Teaching faculty, Physiotherapy, Sri Venkateswara Institute of Medical Sciences, COP

ABSTRACT

Basilar invagination is a rare pathology of craniovertebral junction involving the occipital bone, along with prolapsing of the vertebral column. Basilar invagination with stenosis of the foramen magnum, causing compressive myelopathy at the craniovertebral junction. Clinical symptoms are quadriparesis, spasticity, sensory loss and neck pain and stiffness. There are only a few reports in the literature that describe the role of physiotherapy-based rehabilitation in such cases. Thus, this study was carried out to investigate a case of basilar invagination with Atlanto Axial Dislocation with compressive myelopathy at cranio-vertebral junction. We present the case of a 10-year-old girl child presented with progressive quadriparesis, gait instability, and functional dependence secondary to basilar invagination with atlantoaxial dislocation and craniovertebral junction myelopathy Confirmed on computed tomography of spine. The patient was managed with structured pre-operative rehabilitation program included positioning, respiratory training, spasticity management, balance and postural control exercises, task-oriented functional training, and caregiver education. Following surgical decompression and stabilization, post-operative physiotherapy emphasized early mobilization,

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strength training, coordination, gait re-education, and activities of daily living retraining. Outcomes were assessed using standardized tools including the Barthel Index, Nine-Hole Peg Test and Berg balance scale.

KEY WORDS: Atlanto Axial Dislocation, craniovertebral junction, Basilar invagination, quadriparesis, International Classification of Functioning, Disability and Health, Rehabilitation.

INTRODUCTION

Basilar invagination and atlanto axial dislocation are the most common congenital anomalies of the craniovertebral junction anomalies [1], which is characterized by superior migration of the upper cervical spine into the base of the skull. This results from maldevelopment or structural weakening of the basiocciput, leading to upward displacement of the odontoid process into the foramen magnum and consequent compression at the cervicomedullary junction [6,8].

The etiology of Basilar invagination may be congenital, often remaining asymptomatic until later life, or acquired due to inflammatory, degenerative, or metabolic disorders affecting the craniovertebral junction[8,9]. Progressive Basilar invagination can result in significant neurological compromise [2,6]. Clinical features vary according to the degree of neural compression and commonly include occipital headache, dizziness, paresthesia, limb weakness, gait disturbances, nystagmus, dysphagia, and restricted cervical mobility. Physical findings such as short neck, low posterior hairline, and limited neck movements are frequently observed [2,3].

Diagnosis is primarily radiological [6], established when the odontoid process projects above standard craniometric reference lines such as Chamberlain’s, McGregor’s, and McRae’s lines [6,10]. Management depends on symptom severity, with conservative measures including

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cervical immobilization and physiotherapy considered in stable cases [4], while surgical intervention is indicated in progressive neurological deficits [12]. Rehabilitation including balance training, strengthening and improve functional independence [1].

This case highlights the spasticity, balance abnormality with fall history, difficulty walking(magnetic gait) and fear of falling, this in turn, impacts the individuals ability to perform essential activities of daily living(ADLs) such as bathing, dressing, toileting.

CASE PRESENTATION:

A 10-year-old female, student attending primary school, presented with a history of occasional neck pain associated with neck stiffness, falling to forward, difficulty in initiating walking, spasticity of both upper limbs and lower limbs, since 4 months impaired proprioception and cotton wool sensation and developed quadriparesis since 2 months which impacted her day-to-day life activities leading to partial dependence on her parents.

Initially they consulted neurologist at Guntur they referred to Sri Venkateswara Institute of medical sciences, Tirupati neurosurgery department. Neurosurgeon advised Computed Tomography of Spine revealed Alanto occipital assimilation with mild rotatory defect, Basilar invagination with alanto axial dislocation Retroflexed dens with possible compression over spinal cord at foramen magnum level. Posterior arch of atlas not visualised and neurosurgery team recommended Status post bilateral Occipito-C2 pars-C3 lateral mass fusion with cage placement in bilateral C1-C2 joints.

Preoperatively, the patient was managed conservatively with tab gabapin 200mg, tab pan 20mg, soft cervical collar and post operatively with 1. Tab. Gabapin 400 mg for 14 days 2. Tab. Pantop 20 mg for 10days 3. Tab. Almito for 15 days. 4. Tab. Extil 100 mg for 5 days. 5. Tab. Nureeto MR for 10 days. Patient was referred to physiotherapy department for pre and post operative rehabilitation. She had no relevant medical, surgical, or personal history otherwise.

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This case highlights the positive influence of structured pre-operative physiotherapy rehabilitation on post-operative functional outcomes in pediatric basilar invagination with atlantoaxial dislocation. An ICF-based approach enables comprehensive assessment and targeted intervention across impairment, activity, and participation domains, supporting its integration into multidisciplinary pre-surgical management protocols.

Clinical findings of a patient with Basilar Invagination and Atlantoaxial Dislocation with Craniovertebral Junction Myelopathy:

Table 1: Clinical findings

Clinical domain	Pre operative findings	Post operative findings
Neurological examination	GCS 15/15 (E4V5M6) MMSE: 28/30 Cranial nerves: Intact and elicited Motor examination: Bulk: Normal Tone: MAS grade 1 hypertonia in both upper limb and lower limb MMT: bilateral upper limb and lower limb 3/5 Deep tendon Reflexes: 3+ bilateral upper limb and lower limb plantar flexor response bilateral Sensory: all sensations are intact except proprioception Gait: Magnetic gait	GCS 15/15 (E4V5M6) MMSE: 30/30 Cranial nerves: Intact and elicited Motor examination: Bulk: Normal Tone: Normal MMT: bilateral upper limb and lower limb 4/5 Deep tendon Reflexes: 2+ bilateral upper limb and lower limb plantar flexor response bilateral Sensory: all sensations are intact except proprioception Gait: Magnetic gait
Functional assessment tools	Nine hole peg test Barthel index scale Berg balance scale	Nine hole peg test Barthel index scale Berg balance scale
Radiological findings SPIRAL CT CERVICAL SPINE PLAIN	Alanto occipital assimilation with mild rotatory defect, Basilar invagination with alanto axial dislocation Retroflexed dens with possible compression over spinal cord at foramen magnum level. Posterior arch of atlas not visualised	Status post bilateral Occipito- C2 pars- C3 lateral mass fusion with cage placement in bilateral C1-C2 joints Transpedicular screw fixation noted in C3 and C4 vertebra. Drain tube noted in posterior paravertebral region

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Clinical diagnosis	Basilar Invagination with Atlanto Axial Dislocation with compressive myelopathy at cranio vertebral junction.	Post operative Basilar Invagination with Atlanto Axial Dislocation with compressive myelopathy at cranio vertebral junction.
Surgery proposed	Bilateral Occipito- C2 pars- C3 lateral mass fusion with cage placement in bilateral C1-C2 joints.	Status post bilateral Occipito- C2 pars- C3 lateral mass fusion with cage placement in bilateral C1-C2 joints

RADIOLOGICAL FINDINGS :

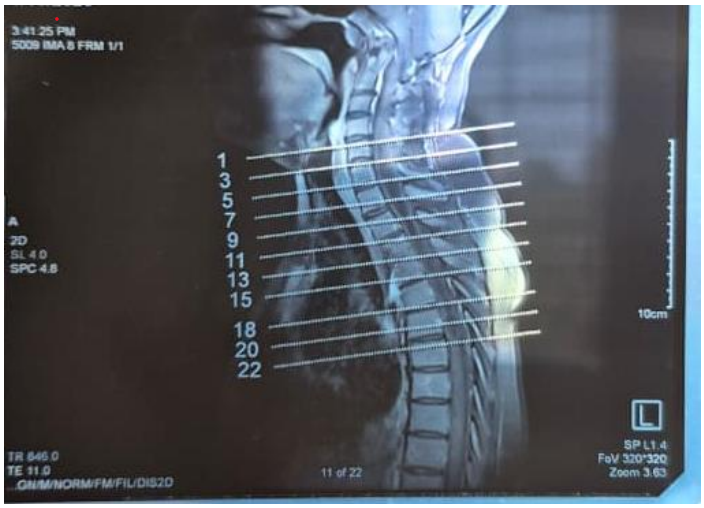

Figure (1)

Showing spiral CT cervical spine Basilar invagination with Increased atlanto-dental interval neutral position - suggestive of Atlanto-axial bony instability. Atlanto occipital assimilation (occipitalisation of atlas) with absent posterior arch of atlas.Foramen magnum is crowded due to upward migration of odontoid process and atlanto occipital assimilation.

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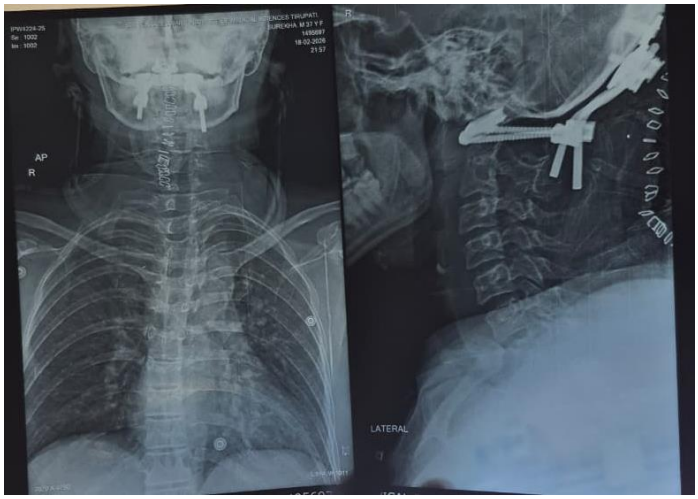

Figure (2)

Chest Xray in AP and lateral veiw showing Occipital plate fixation with C1-C2 fusion and interfacet cage in situ. 2. Minimal postop changes in the posterior paravertebral soft tissues in the suboccipital region and in the upper cervical region with drain tube in situ and Interval improvement in basilar invagination and atlanto-axial instability

PHYSIOTHERAPY INTERVENTIONS:

Table 2:Pre operative rehabilitation protocol:

Therapeutic intervention	Dosage	Duration	Outcome measurement
Spasticity management with stretching followed by quick icing technique	30-60 seconds hold and stretch /3 sets	15mins per session	Modified Ashworth scale
Strength training	10repititions/ 3sets	15mins/session	MMT and MRC scale
Grip strength training	10-15 repititions	15mins/session	Functional hand assessment by 9 hole peg test

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Balance and coordination exercises	15 repititons/ exercise	15mins/session	Berg balance sacle
Functional re-education	5-10 repititions /task	30mins/session	Barthel index
Task specific exercise	7 repitions /task	20mins/ session	Barthel index

Table 3:Post operative rehabilitation protocol

Post-op Days	Intervention	Dosage	Duration / Frequency	Expected Outcome
Day 1–2	Positioning & pressure care	Reposition every 2 hours	Continuous + 2 PT sessions/day	Pain reduction, prevention of pressure sores
Day 1–2	Breathing exercises	10 reps × 3 sets	10–15 min/session	Improved chest expansion and oxygenation
Day 1–2	Passive / assisted ROM (distal joints)	10 reps per joint	15–20 min/session	Maintenance of joint mobility
Day 3–4	Bed mobility (log rolling)	5–8 repetitions	20 min/session	Initiation of controlled movement

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Day 3–4	Assisted AROM (UL & LL)	10 reps × 2 sets	20 min/session	Improved voluntary muscle activation
Day 3–4	Sensory stimulation	5–7 min per limb	Once daily	Enhanced sensory awareness
Day 5–7	Isometric exercises (UL, LL, trunk)	Hold 5 sec × 10 reps	20–25 min/session	Improved muscle recruitment
Day 5–7	Supported sitting balance	Hold 5–10 min	2–3 trials/session	Improved postural control
Day 5–7	Weight shifting in sitting	10 reps × 2 sets	20 min/session	Improved balance reactions
Day 8–10	Active ROM against gravity	10–15 reps × 2 sets	25–30 min/session	Increased strength and coordination
Day 8–10	Sit-to-stand training (assisted)	5–8 repetitions	20 min/session	Functional lower-limb activation
Day 8–10	Reaching and grasping tasks	10–12 task trials	20 min/session	Improved hand function
Day 11–14	Standing balance training	Hold 30–60 sec × 5 trials	25–30 min/session	Improved static balance
Day 11–14	Gait initiation with aid	5–10 min walking	Once daily	Improved gait pattern
Day 11–14	ADL-based task practice	Task-specific repetitions	30 min/session	Improved functional independence

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4 weeks of total rehabilitation protocol is given to the patient 2 weeks pre operatively and 2 weeks post operatively comprising interventions such as cryotherapy ,balance exercises, task-oriented training with activities of daily living (ADL) re-education ,early mobilization and strengthening.

Notably, significant functional improvements were observed in balance, spasticity reduction, and ADL performance over the treatment duration.

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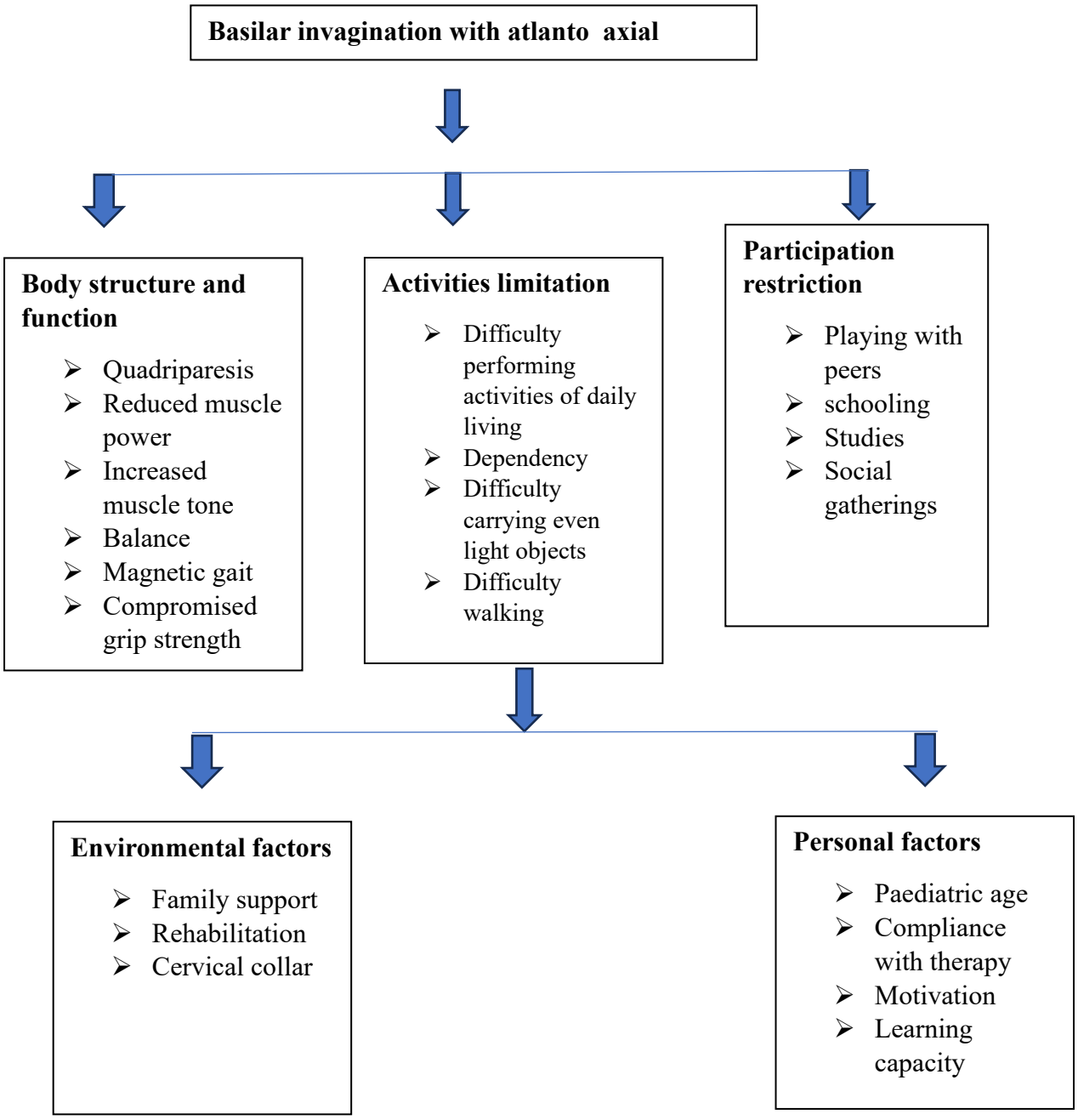
International Classification of Functioning, Disability and Health (ICF) model:



Flow chart 1: ICF MODEL

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OUTCOMES:

The patient was evaluated pre- and post-intervention using standardized outcome measures. Prior to treatment, There is a significant clinical improvements were observed over the 4-week rehabilitation period prior to surgery and after surgery.

The patient reported enhanced balance, decreased spasticity and increased independence in daily activities. These improvements were supported by quantifiable gains in outcome measures such as the nine hole peg test [15], Berg Balance Scale (BBS) [16], and Barthel Index[17]. Early initiation of physiotherapy, combined with task-specific and postural stability training, contributed to the favorable recovery.

The outcomes taken are;

1) Nine hole peg test[15]

2) Berg Balance Scale [16]

3) Barthel Index[17]

Table 4:Pre and Post Treatment Outcome Measures Table:

Outcome measure	Pre operative	Post operative	Interpretation
Nine hole peg test	Rt 48 seconds Lt 52 seconds	Rt 30 seconds Lt 42 seconds	Significant improvement in fine grasp
Berg Balance Scale	35/56-moderate fall risk	48/56-mild fall risk	Improved balance and reduced fall risk

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Barthel Index	35/100-severe dependency	75/100-moderate dependency	Increased independence in activities of daily living

RESULTS:

After completing a 4-week preoperative rehabilitation program, the patient exhibited significant improvements in spasticity reduction by nine hole peg test, hand function like gasping, The Berg Balance Scale (BBS) score improved from 35 out of 56 pre-treatment, reflecting a moderate fall risk, to 48 out of 56 post-treatment, corresponding to a mild fall risk. This demonstrates enhanced balance and a lowered risk of falls. Functional assessment with the Barthel Index showed an increase from 35/100 pre-treatment, indicating severe dependency in activities of daily living, to 75/100 post-treatment, reflecting moderate dependency and increased functional independence.

These quantitative improvements underscore the effectiveness of the of Structured Pre-operative Physiotherapy Rehabilitation on Post-operative Outcomes in a Child with Basilar Invagination and Atlantoaxial Dislocation with Craniovertebral Junction Myelopathy.

DISCUSSION:

Basilar invagination is a rare pathology at the craniovertebral junction of the cervical spine. It is a condition that happens whenever the floor of the skull at the foramen magnum has grown in such a way that the superior aspect of the upper spine is more cephalad, which actually results in a constriction of the foramen magnum opening and prolapsing of the odontoid process [1,9]. The cause of this abnormality is either congenital or degenerative. Congenital basilar

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invagination may remain asymptomatic and unrecognized until adulthood. When symptoms progress and threaten disability, basilar invagination (BI) results in severe neurological, anatomical, and respiratory disturbances within the body. Clinical features of basilar invagination include headache, dizziness, loss of sensation, tingling numbness around hands and feet, weakness, nystagmus, difficulty swallowing, and restricted neck ranges [2,11]. Restricted neck movements (59 percent), a low hairline (48 percent), a webbed neck (57 percent), and a short neck were among the localized findings [2,3]

The prevalence rate of BI is less than one percent in the general population. Moreover, it is attributed to softening of the osseous structures at the base of the skull [4,13]. It is a rare condition that can have multiple causes. The most common causes include Chiari malformation, arthritis, syringomyelia, and Klippel-Fiel disease [5]. The diagnosis of basilar invagination is usually made through radiological investigations when the tip of the odontoid process of the cervical spine crosses the line of Chamberlain's [6]. Further diagnoses depend on the Chamberlain line, the McGregor line, and the McRae line [7].

Basilar invagination (BI) often manifests as the upward movement of the dentate process, which then compresses the brainstem. The condition presents with clinical symptoms requiring surgical treatment. In 2004, Goel divided the disease into group A (BI with atlantoaxial dislocation [AAD]) and group B (BI without AAD) [14].

Conservative treatments include methods like physical therapy, anti-inflammatory medication, or a neck brace. Physiotherapists cite anecdotal evidence of the clinical effectiveness of soft collars. Physiotherapy will include exercises and electrotherapy modalities[1,2]. The severity of the affliction determines how the condition can be managed. To alleviate the symptoms, treatments such as gabapentin medication and physical therapy can be used.[8]

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Basilar invagination (BI) is a rare craniovertebral junction pathology characterized by upward migration of the upper cervical spine into the skull base, resulting in foramen magnum constriction and prolapse of the odontoid process [1,9]. It may be congenital or degenerative, with congenital forms often remaining asymptomatic until later stages. Progressive BI can lead to significant neurological, anatomical, and respiratory impairments. Clinical features include headache, dizziness, sensory disturbances, limb weakness, nystagmus, dysphagia, and restricted cervical mobility, along with physical findings such as short neck, low hairline, and limited neck movements [2,3,11].

The prevalence of BI is less than 1% and is associated with structural abnormalities of the skull base [4,13]. Common etiologies include Chiari malformation, arthritis, syringomyelia, and Klippel-Feil syndrome [5]. Diagnosis is primarily radiological, based on the odontoid process crossing reference lines such as Chamberlain's, McGregor's, and McRae's lines [6,7]. BI may be classified into types with or without atlantoaxial dislocation [14].Management depends on severity and includes conservative approaches such as physiotherapy, medications, and cervical support, or surgical intervention in progressive cases [1,2,8].

This case demonstrates the effectiveness of Prehabilitation on normalizing spasticity, improving strength, and enhancing balance, thereby these interventions likely helped optimize the child's physical status before surgery, thereby facilitating early mobilization and smoother functional recovery following surgical intervention. Preparing the neuromuscular system in advance may also reduce post-operative complications related to immobility and deconditioning.

Following surgery, a graded post-operative rehabilitation program was implemented, progressing from positioning and respiratory care to active movement, balance training, gait initiation, and activities of daily living retraining. The phased approach allowed safe restoration

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of function while respecting surgical precautions. Incorporation of motor learning principles ensured appropriate progression from cognitively guided movements to more autonomous functional tasks, which is particularly important in paediatric neurorehabilitation.

Objective outcome measures demonstrated meaningful functional improvement. Reduced completion time in the Nine-Hole Peg Test indicated improved fine motor coordination and hand dexterity, essential for self-care and academic activities. Improvement in the Berg Balance Scale score reflected enhanced postural stability and reduced fall risk, while gains in the Barthel Index score indicated improved independence in daily activities. These findings suggest that physiotherapy contributed not only to impairment-level recovery but also to improved activity performance and participation.

The use of the International Classification of Functioning, Disability and Health (ICF) framework [15] allowed a comprehensive understanding of the child's condition by addressing body structure and function, activity limitations, participation restrictions, and contextual factors. Personal factors such as young age, motivation, and learning capacity, along with environmental support from family and rehabilitation services, positively influenced outcomes. This holistic approach supports the integration of physiotherapy as a core component of multidisciplinary management in craniovertebral junction disorders.

Although the findings from this single case cannot be generalized, they provide valuable clinical insight into the potential impact of early and structured rehabilitation in paediatric basilar invagination with atlantoaxial dislocation. Further studies with larger sample sizes and long-term follow-up are required to strengthen the evidence base.

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CONCLUSION

This case study demonstrates that prehabilitation can significantly enhance functional outcomes in a child with basilar invagination and atlantoaxial dislocation complicated by craniovertebral junction myelopathy. Early physiotherapy intervention contributed to reductions in spasticity, improvements in balance, hand function, gait, and increased independence in activities of daily living.

Applying an **ICF-based rehabilitation approach** enabled holistic management by addressing impairments, functional limitations, and participation restrictions while considering personal and environmental factors. The findings emphasize that physiotherapy should be considered an integral component of multidisciplinary care alongside surgical management in paediatric craniovertebral junction anomalies. Further research is recommended to establish standardized rehabilitation protocols and to evaluate long-term functional outcomes in this population.

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CONSENT FORM

I _____ {name} voluntarily give consent to participate in the study entitled in doing so I affirm that: **EFFECT OF PREHABILITATION ON POST-OPERATIVE OUTCOMES IN A CHILD WITH BASILAR INVAGINATION - CASE STUDY.** I have been given full information in my native language about the study and have understood the purpose and nature of the study and the potential risks to me resulting from my participation in the study.

- I have been given ample opportunity to ask questions, which have been answered to my satisfaction.
- I understand that my participation in the study is purely voluntary and that unwillingness/refusal to participate will not adversely affect the medical care due to me.
- I have been assured that there is no additional medical expenditure to be incurred by me on account of my participation in the study.
- That I faced no coercion to sign this consent form.

I have been informed that notwithstanding my signing this consent, I can withdraw from the study at any point of time, without it compromising in any way, the medical care to which

Signature of patient/guardian:	Signature of Witness:	Signature of Investigator:
Name of patient:	Name of Witness:	Name of Investigator:
Date:	Date:	Date:
Place:	Place:	Place:

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