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Comprehensive Physical Therapy Management in a 4-Year-Old Male with Congenital Insensitivity to Pain with Anhidrosis (CIPA): A Case Report

Vivek Ramanandi

vivek.ramanandi@marwadieducation.edu.in

Marwadi University

Aparna Bachkaniwala

Veer Narmad South Gujarat University

Case Report

Keywords: Anhidrosis, Charcot joints, Congenital insensitivity to pain, Hereditary sensory and autonomic neuropathy type IV, Physical therapy, Self-mutilation, Proprioceptive training

Posted Date: November 16th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11502107/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Congenital Insensitivity to Pain with Anhidrosis (CIPA), also known as Hereditary Sensory and Autonomic Neuropathy Type IV (HSAN-IV), is a rare autosomal recessive disorder. The condition is clinically characterized by a complete absence of pain and temperature perception, anhidrosis, and varying degrees of intellectual disability. The inability to perceive nociceptive stimuli often leads to severe, recurrent micro- and macrotraumas. Common complications of CIPA include self-mutilation, recurrent painless fractures, undetected osteomyelitis, and the rapid progression of neurogenic arthropathy (i.e., Charcot joints). Because the underlying pathology is irreversible, preventive rehabilitation is essential; however, standardized physical therapy protocols for CIPA remain virtually non-existent in the current literature.

Case Presentation:

A 4-year-old male child, genetically confirmed to have CIPA, presented to the neurological rehabilitation department of an institution-based outpatient department, following a history of recurrent unexplained fevers, frequent painless falls, and extreme self-mutilating behavior that resulted in partial fingertip amputation. Clinical neurological examination confirmed a complete absence of superficial and deep pain perception across all dermatomes, as well as generalized joint hypermobility and hypotonia.

Management and Outcomes:

The rehabilitation team initiated a highly targeted, interdisciplinary physical therapy intervention over 6 months. The protocol included gross motor development, advanced balance and proprioceptive training to compensate for sensory loss, joint-stabilization exercises, and orthotic management. Additionally, caregiver education emphasized thermoregulation and systematic visual inspections of skin on a daily basis. During follow-up, the patient showed significant improvements in dynamic postural stability, measured by standardized pediatric balance scales, and functional mobility. Prescription of a protective orthotic device resulted in the absence of new self-inflicted injuries. Caregiver vigilance was important in early identification of a unilateral knee effusion, which enabled prompt orthopedic immobilization and prevented secondary Charcot arthropathy.

Conclusion

Physical therapy is an essential primary intervention in the interdisciplinary management of CIPA, not merely an adjunct. Early intervention that focuses on proprioceptive compensation, comprehensive orthotic protection, and intensive caregiver education is crucial to preventing musculoskeletal

deformities, reducing morbidity, and improving these vulnerable pediatric patients' long-term quality of life.

Introduction

Congenital Insensitivity to Pain with Anhidrosis (CIPA), clinically classified as Hereditary Sensory and Autonomic Neuropathy Type IV (HSAN-IV), is an exceptionally rare and severe autosomal recessive neurogenetic disorder. While its precise incidence is unknown, it is reported to be more prevalent in populations where consanguineous marriages are common. CIPA pathogenesis is documented to be associated with loss-of-function mutations in NTRK1, which is located on chromosome 1q21–q22. NTRK1 encodes neurotrophic tyrosine kinase receptor 1 (TrkA), the primary receptor for nerve growth factor (NGF) [1, 2]. During embryonic development, NGF–TrkA signaling is essential for the survival, proliferation, and maturation of neurons associated with nociceptive and postganglionic sympathetic functions. In CIPA, these functions are disrupted, impairing the development of neural crest-derived nociceptive and postganglionic sympathetic neurons. This ultimately leads to profound insensitivity to pain and temperature along with anhidrosis, due to the absence of sympathetic innervation to the eccrine sweat glands.

The clinical features of CIPA typically present during early infancy, often leading to a diagnostic challenge. Infants commonly experience recurrent, unexplained febrile episodes that may become life-threatening because of impaired thermoregulation. It is reported that approximately 20% of the affected children who are not recognized as having CIPA and remain unmanaged, hyperpyrexia can be proven fatal before age three [3]. As children with CIPA develop mobility and primary dentition, the absence of protective nociceptive feedback can lead to severe, cumulative trauma. They may engage in substantial self-injury, including biting the tongue, lips, and fingertips, sometimes resulting in auto-amputation or tooth loss through auto-extraction. The musculoskeletal system is also affected, leading to multiple painless fractures, unrecognized deep-tissue infections such as osteomyelitis, and progressive joint destruction that can cause neurogenic arthropathy, commonly known as Charcot joints. [4, 5].

Because these complications are complex and multisystemic, interdisciplinary coordination among team members, such as pediatricians, orthopedic surgeons, geneticists, dentists, dermatologists, and rehabilitation specialists, is required for effective overall management. Although the scientific literature documents various surgical and pharmacological interventions, such as fracture management and antibiotic treatment for osteomyelitis, preventative and rehabilitative physical therapy for acute CIPA complications are underexplored [6].

Because pain usually serves as a physiological protective mechanism that limits musculoskeletal loading, physical therapists must assume the role of an "external nociceptor" when it is absent. We present a detailed analysis of physical therapy management for a 4-year-old boy with CIPA, highlighting our clinical decision-making, targeted interventions, behavioral adaptations, and caregiver education to manage long-term morbidity.

Case Presentation

Patient Information and History

A 4-year-old boy was referred by a pediatric geneticist to an institution-based outpatient physiotherapy department for recurrent falls, generalized hypotonia, and functional mobility training. He was born at 39 weeks' gestation by unassisted vaginal delivery to parents who were first cousins. There was no significant postnatal history reported; however, at the age of 4 months, the child started experiencing recurrent high-grade fevers of unknown origin, leading to frequent hospital admissions.

The confirmed diagnosis of this rare genetic disorder was delayed and complex. The child sustained two tibial fractures following episodes of minor falls, without apparent distress or crying; he was initially diagnosed as having mild osteogenesis imperfecta at the age of 18 months. The child started displaying severe self-injurious behavior, including chronic fingertip biting and extraction of the mandibular incisors at approximately 2 years of age, which led to suspicion of sensory neuropathy.

Clinical and Neurological Findings

A comprehensive physical therapy evaluation found the child to be alert, cooperative, and normocephalic. Mild delays in gross motor development were noted; independent ambulation was achieved at approximately 22 months.

Integumentary and musculoskeletal examinations revealed extensive hyperpigmented scarring on both lower extremities, forearms, and hands. The distal phalanx of the left index finger and the right thumb had been partially auto-amputated, with thick, calloused tissue consistent with chronic mechanical trauma. The oral examination showed that the upper and lower central incisors were absent, along with significant fibrotic scarring along the sides of the tongue, lower lip, and inner cheeks.

Neurological examination revealed a complete absence of responses to superficial pain, assessed by pinprick, and deep pain, assessed by pressure over the Achilles tendon, across all major dermatomes. Temperature discrimination, assessed using hot and cold test tubes, was also absent. In contrast, patellar and Achilles deep tendon reflexes, vibration sense, assessed with a 128-Hz tuning fork, and crude touch perception remained intact, indicating a selective neuropathy affecting unmyelinated and small myelinated nerve fibers.

Motor examination demonstrated symmetric hypotonia in the upper and lower extremities bilaterally, with a Modified Ashworth Scale score of 0. The Beighton Score was 7/9, indicating generalized joint hypermobility. The combination of hypotonia, absent pain feedback, and joint hyperlaxity placed the patient at substantially increased risk of unrecognized subluxations, dislocations, and repetitive microtrauma during weight-bearing activities.

Diagnostic Assessment

Baseline laboratory investigations, including a complete blood count and metabolic panel, were unremarkable. Electroencephalography (EEG) findings were normal, excluding central seizure activity as a cause of the falls. Electromyography (EMG) and nerve conduction studies demonstrated normal motor and large-fiber sensory nerve action potentials, a characteristic finding in congenital insensitivity to pain with anhidrosis (CIPA), which selectively affects small unmyelinated (C) and thinly myelinated (Aδ) fibers. Radiographs of the lower extremities showed bilateral cortical thickening and sclerosis of the tibiae and fibulae, consistent with multiple healed, previously unrecognized stress fractures. Whole-exome sequencing identified a homozygous pathogenic variant in the NTRK1 gene, confirming the diagnosis of CIPA.

Physical Therapy Management

Physical therapy required a novel approach, different from conventional rehabilitation. Because pain cannot serve as a warning signal in CIPA, therapists must implement mechanical and cognitive safeguards to minimize tissue damage. Treatment goals included improving mobility and postural stability to reduce fall risk, preventing neuropathic arthropathy, and educating caregivers on strategies to prevent secondary injuries. The intervention plan comprised an intensive phase of two 45-minute sessions per week for 12 weeks, followed by transition to a closely monitored home-based program.

1. Mobility, Biomechanics, and Joint Stabilization

In the absence of nociceptive feedback, the patient lacked protective muscle guarding, allowing potentially harmful ranges of motion. This contributed to an inefficient, wide-based, pronated gait that placed abnormal stress on the medial aspects of the knees and ankles.

Exercises emphasized closed-chain activities to promote joint co-contraction and stability. Interventions included:

● Core and Proximal Stability: Exercises such as modified quadruped weight shifts, bridging on a therapy ball, and kneeling-to-standing transitions were used to strengthen the pelvic girdle and abdominal core.

● Lower-Extremity Strengthening: Strengthening exercises specifically targeted the gluteus medius, quadriceps, and hamstrings to provide dynamic muscular support for the hip and knee joints. These joints are particularly susceptible to rapid degeneration and Charcot arthropathy in sensory neuropathies [7]. Exercises included assisted step-ups, wall sits (with strict time limits to prevent pressure necrosis), and resisted side-stepping.

2. Advanced Balance and Proprioceptive Training

Impaired sensory feedback from small fibers, combined with generalized hypotonia, severely compromised the child's dynamic postural control [8]. As a result, the patient exhibited frequent unprovoked falls during ambulation, due to poor somatosensory integration.

Balance training was initiated in varied sensory environments to encourage the central nervous system to rely primarily on intact visual and vestibular inputs. Interventions included:

● Standing and marching on uneven, compliant surfaces (e.g., high-density foam pads and wobble boards).

● Tandem-stance and single-leg-stance training, with age-appropriate adaptations such as kicking a stationary ball.

● Visual feedback integration: Mirror therapy was used extensively during gait training and balance exercises to help the child visually assess his body position in space, thereby compensating for the absence of nociceptive and temperature-related afferent input during movement.

3. Aggressive Orthotic Prescription and Protective Gear

To combat the severe self-mutilation and protect mechanically vulnerable joints, an aggressive, proactive orthotic approach was implemented, far exceeding standard pediatric orthotic usage [9, 10].

● Lower Extremity Orthoses: Bilateral custom-molded, solid-ankle supramalleolar orthoses (SMOs) were prescribed to correct severe bilateral foot pronation, support collapsing arches, and limit ankle inversion and eversion during gait. By aligning the subtalar joints, they reduce shear forces that can cause painless sprains, microfractures, and neurogenic arthropathy. Plastazote lining minimizes friction and pressure ulcers the child may not feel.

● Upper Extremity Protection: Specialized padded protective gloves, seamlessly tailored for daily wear, were recommended. They served two purposes: blocking the child's access to his fingertips to stop chewing and self-amputation behaviors, and providing mechanical protection against burns and blunt trauma during play.

● Dental Protection: We collaborated with a pediatric dentist to facilitate the fabrication of a custom, soft silicone oral bite guard, which was worn primarily during periods of high stress or unattended sleep to prevent further intraoral mutilation and tongue biting.

4. Caregiver Education and Environmental Modification Protocol

Education was deemed the most critical, life-saving component of the rehabilitation process [11, 12], so the physical therapist extensively trained the parents in a "Home Management and Environmental Modification Protocol," which included:

● Mandatory Visual Skin Inspections: Parents received training in conducting thorough, full-body skin examinations twice daily. They were instructed to identify subtle signs of inflammation, such as localized erythema, mild swelling, or localized warmth, which may be the only indicators of underlying fractures, joint effusion, or early osteomyelitis [13].

● Thermoregulation Strategies: Because the child was unable to sweat, his parents were taught to monitor his temperature and recognize signs of hyperthermia, including flushed skin, lethargy, a rapid heartbeat, and irritability. They were advised to use cooling vests and a portable misting fan outdoors and restrict strenuous activity when temperatures exceeded 24°C (75°F).

● Activity Modification and Behavioral Redirection: To minimize repetitive joint loading, high-impact activities (e.g., jumping, trampoline use, and contact sports) were contraindicated. The therapist assisted the family in selecting safe alternatives, including temperature-controlled swimming and stationary cycling. Parents were also taught to gently redirect self-injurious chewing by offering safe sensory toys.

Outcomes and Follow-up

The patient's progress was documented and reassessed at 3 and 6 months. Throughout follow-up, the parents adhered closely to the home exercise program, thermoregulation protocols, and protective orthotics.

Pediatric-specific measures showed improvement. The Pediatric Balance Scale score rose from 38/56 to 49/56, indicating better dynamic balance and reduced fall risk. Parents reported about 75% fewer unprovoked falls, alongside improved proximal strength and proprioceptive compensation.

Padded protective gloves stopped the chronic finger-chewing habit, allowing the hand tissue to heal without recurrent infection.

Caregiver education proved especially valuable at month 4. During an evening skin check, the mother noticed painless swelling and warmth over the right knee, although the child walked normally and had no symptoms. Following the therapy protocol, the parents restricted weight-bearing and sought orthopedic care. Radiography showed an early knee effusion and a nondisplaced micro-trabecular fracture of the proximal tibia. A long-leg cast was applied for four weeks. Early detection and conservative treatment prevented progression to a Charcot joint. No further fractures or osteomyelitis occurred during follow-up.

Discussion

Congenital Insensitivity to Pain with Anhidrosis (CIPA) creates a clinical paradox: the body's protective pain mechanism is absent. Patients and caregivers must compensate through cognitive strategies, environmental modifications, and constant visual monitoring. This case report emphasizes that physical therapy is not simply an adjunct but a preventive necessity for long-term survival and independence.

In pediatric rehabilitation, pain provides critical feedback by setting exertion limits, signaling the need for rest, and restricting joint movement to prevent injury. For children with CIPA, therapists must anticipate mechanical failure. Often called the "mystery of broken bones," CIPA is initially misdiagnosed as osteogenesis imperfecta [14]. But unlike its intrinsic bone fragility, CIPA fractures result from repetitive overloading without protective guarding.

This case's emphasis on proprioception and balance reflects neurorehabilitation principles used for sensory neuropathies, including pediatric diabetic neuropathy and Charcot-Marie-Tooth disease, where improved postural stability can reduce traumatic falls [8, 15]. Custom SMOs were essential in preventing neuropathic arthropathy secondary to joint hypermobility, which, when combined with pain insensitivity, can trigger Charcot arthropathy [7]. By stabilizing the ankle-foot complex and aligning the lower-extremity kinetic chain, SMOs reduced abnormal stress and helped protect developing joints.

We identify the integration of extensive, structured caregiver training into the formal physical therapy protocol as a defining and novel aspect of this case report. Because individuals with CIPA cannot self-report injuries, the prevention of catastrophic complications such as deep bone osteomyelitis relies completely on early visual identification [13]. At month 4, the mother reported successfully identifying the knee effusion, supporting the educational intervention's efficacy. This finding represents a significant shift in the management of CIPA, empowering parents to take a leading role in identifying musculoskeletal trauma.

Although this case shows highly positive short-term outcomes, managing CIPA remains a lifelong challenge. Robust long-term trials and systematic reviews of physical therapy modalities are lacking, largely because the disease is extremely rare, limiting large studies [16]. Early developmental intervention, careful orthotic management, sensory compensation training, and caregiver education may provide a safe, reproducible, effective framework for physiotherapy management of patients with CIPA.

Conclusion

Physical therapy can play an essential part in the interdisciplinary management of congenital insensitivity to pain with anhidrosis (CIPA). For children with CIPA, individualized rehabilitation should emphasize joint stabilization, visual-proprioceptive compensation, orthotic protection, and caregiver education to reduce risk of self-injury and orthopedic trauma. Proactive rehabilitation and environmental adaptations may improve functional outcomes. Further case documentation and international collaboration are needed to develop evidence-based physical therapy guidelines for this rare neurogenetic condition.

Declarations

Competing interests:

The author declares that they have no competing interests.

Ethics approval:

Not applicable. This report details standard, non-experimental clinical care.

Consent to participate and publish:

Written informed consent was obtained from the parents of the patient for the publication of this case report and any accompanying non-identifiable clinical data.

Funding:

No funds, grants, or other support were received.

Author Contribution

V.R.: Conceptualization, methodology, writing – original draft. A.B.: Writing – review and editing. V.R. and A.B.: Both authors approved the final manuscript.

Acknowledgement

The authors thank the child and his parents for their cooperation throughout the rehabilitation and follow-up process.

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