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Mirror Movements: A Narrative Review of an Under-recognized Pediatric Disorder in Sub-Saharan Africa

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ABSTRACT

Background: Congenital Mirror Movements are rare neurodevelopmental disorders characterized by involuntary movements on one side of the body that mirror voluntary movements on the opposite side, most commonly involving the hands. Mild mirror movements may occur during normal early childhood development; however, persistence beyond the expected age suggests abnormal corticospinal tract organization. Congenital forms arise from developmental abnormalities in corticospinal tract decussation, while acquired mirror movements may occur after neurological insults such as stroke, traumatic brain injury, or other central nervous system disorders. In Sub-Saharan Africa, limited clinician awareness and restricted pediatric neurology services contribute to under-recognition and delayed diagnosis. **Aim:** This narrative review synthesizes current evidence on the epidemiology, genetic mechanisms, pathophysiology, clinical presentation, diagnosis, and management of mirror movements, with particular attention to challenges and practical considerations in Sub-Saharan Africa. **Methods:** Peer-reviewed literature, including original research articles, case reports, and review papers on mirror movements, was analyzed. Evidence from clinical, neurophysiological, neuroimaging, and genetic studies was examined alongside publications describing pediatric neurology capacity and diagnostic limitations in resource-constrained settings. **Data Synthesis:** Congenital mirror movements are lifelong, non-progressive conditions frequently associated with mutations in genes such as DCC and RAD51, leading to abnormal corticospinal tract development. Acquired mirror movements arise after neurological injury. Both forms may impair fine motor coordination, and diagnosis in resource-limited settings remains largely clinical. **Conclusion:** Mirror movements remain under-recognized in Sub-Saharan Africa. Strengthening clinician awareness, incorporating mirror movement assessment into routine neurological examination, promoting early rehabilitation, and improving pediatric neurology capacity are essential to enhance detection, optimize functional outcomes, and reduce disparities in neurological care.

Keywords: Congenital mirror movements, Pediatric movement disorders, Corticospinal tract, Neurodevelopmental disorders, Sub-Saharan Africa

INTRODUCTION

Congenital Mirror Movements are rare neurodevelopmental motor disorders characterized by involuntary movements on one side of the body that mirror intentional movements performed by the contralateral homologous muscles, most prominently affecting the hands and fingers.[1] These movements occur simultaneously with voluntary activity and typically persist throughout life without progressive neurological deterioration.

Although subtle mirror activity may be observed during early childhood as part of normal motor development, persistent and pronounced mirror movements beyond the expected developmental period are considered pathological and may indicate underlying abnormalities in corticospinal tract organization.[2]

The phenomenon of mirror movements has long attracted clinical interest. Early neurologists in the late nineteenth century described involuntary movements occurring in one limb during voluntary movements of the contralateral limb, distinguishing them from the transient associated movements commonly observed during normal motor maturation in infancy. Subsequent clinical and neurophysiological studies have further clarified the characteristics and mechanisms of mirror movements, underscoring their relevance in both developmental and acquired neurological conditions.[3,4]

Over time, persistent mirror movements were increasingly recognized as a distinct neurological phenomenon rather than a benign developmental variant, with the provision of a widely accepted definition,

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describing it as involuntary synkinetic movements that mirror the intended voluntary activity of the opposite limb [2]

By the early twentieth century, accumulating clinical observations linked persistent mirror movements to structural and developmental abnormalities of the motor system, leading to the recognition of congenital mirror movements as a distinct clinical entity. Patients typically presented with lifelong mirror movements beginning in early childhood, normal cognitive development, and no progressive neurological disease. In many cases, clinicians also observed a positive family history, suggesting a genetic basis for the disorder.[5]

Subsequent advances in molecular genetics significantly improved the understanding of the condition. A major breakthrough occurred in the early twenty-first century when mutations in the DCC (Deleted in Colorectal Carcinoma) gene were identified as a cause of autosomal dominant congenital mirror movements.[5] Later studies demonstrated additional genetic heterogeneity, including mutations involving the RAD51 gene, further establishing congenital mirror movements as a disorder of axonal guidance and abnormal corticospinal tract development.[2]

Congenital mirror movements are a rare, non-progressive neurodevelopmental motor disorder resulting primarily from abnormal decussation of the corticospinal tract during embryonic development.[1] In affected individuals, motor commands transmitted through the corticospinal tract activate both sides of the body simultaneously, producing symmetrical movements instead of the normal unilateral motor control. In contrast, acquired mirror movements arise later in life following neurological insults such as stroke, traumatic brain injury, or other central nervous system disorders.[6] Although both forms share similar clinical manifestations, their underlying mechanisms and clinical contexts differ. Congenital forms typically appear during infancy or early childhood and remain stable throughout life, whereas acquired mirror movements reflect adaptive or maladaptive changes in motor pathways following injury.[6]

Despite their distinctive clinical features, mirror movements remain under-recognized in routine clinical practice. Because affected individuals usually retain normal intelligence, preserved neurological function, and normal life expectancy, the condition may be overlooked or misinterpreted as a benign motor quirk.[7] In some settings, individuals with mirror movements may even be perceived as having unusual motor "skills" rather than a neurological disorder. Such misconceptions can delay appropriate evaluation and management.[8]

The challenge of recognition is particularly pronounced in low- and middle-income regions, including Sub-Saharan Africa, where neurological services remain limited. Shortages of trained pediatric neurologists, limited access to specialized diagnostic tools such as neurophysiological testing and neuroimaging, and low awareness of rare neurodevelopmental disorders contribute to diagnostic delays and underreporting.[9] In addition, sociocultural interpretations of unusual motor behaviors may further obscure recognition of the disorder.[10] Consequently, the true burden of congenital mirror movements in Sub-Saharan Africa remains poorly understood.[11]

Given these challenges, a comprehensive synthesis of current knowledge is needed to improve recognition and clinical understanding of this rare disorder in resource-limited settings. This narrative review, therefore, examines the epidemiology, genetic mechanisms, pathophysiology, clinical presentation, diagnosis, and management of mirror movements, with particular emphasis on the contextual challenges and practical considerations relevant to Sub-Saharan Africa. By highlighting the clinical significance of this under-recognized condition, the review aims to contribute to improved awareness, earlier diagnosis, and more effective management within pediatric neurological practice in the region.

METHODS

A comprehensive literature search was performed in MEDLINE (via PubMed), ScienceDirect, and Google Scholar for full-text articles published up to February 2026. Search terms included combinations of the following keywords: "mirror movements," "congenital mirror movements," "corticospinal tract," "DCC gene," "RAD51 gene," "neuroimaging," "transcranial magnetic stimulation," and "electromyography." Additional relevant publications were identified through manual screening of the reference lists of retrieved articles. Studies were eligible for inclusion if they reported clinical, neurophysiological, neuroimaging, or genetic findings related to mirror movements. Eligible study designs included case reports, case series, observational studies, and narrative or systematic reviews published in English.

Studies lacking sufficient methodological detail, non-human studies, conference abstracts, and non-peer-reviewed reports were excluded. Titles and abstracts of retrieved records were screened for relevance, followed by full-text assessment of potentially eligible articles.

Data from included studies were synthesized qualitatively due to heterogeneity in study designs and outcomes. Extracted information focused on clinical assessment methods and grading scales (including the Woods and Teuber classification and the Cohen Mirror Movement Scale), neurophysiological and neuroimaging findings, genetic etiologies, epidemiological patterns, and the functional and psychosocial impact of mirror movements. Particular attention was given to differences between physiological mirror movements observed during normal development and pathological mirror movements associated with neurodevelopmental or neurological disorders. Case reports and small series were included to illustrate rare clinical presentations, but were interpreted with caution regarding prevalence and generalizability. The synthesis also considered recognized gaps in the literature, particularly the limited epidemiological data and restricted access to specialized diagnostic resources in Sub-Saharan Africa, which may contribute to under-recognition of the condition.

DATA SYNTHESIS

Epidemiology and Global Distribution

Congenital mirror movements (CMM) are extremely rare neurodevelopmental motor disorders, with an estimated prevalence of below 1 per 1,000,000 individuals. However, this figure likely underestimates the true burden due to mild phenotypes, variable clinical severity, and limited awareness among clinicians. Some reports suggest mirror movements occur in approximately 1 in 8,000 men and 1 in 40,000 women, suggesting possible male predominance, although referral bias and incomplete penetrance may influence these estimates. Familial cases typically follow an autosomal dominant inheritance pattern, though sporadic cases also occur.[1,7,12,13]

The majority of epidemiological and genetic data originate from Europe, particularly France, the United Kingdom, Germany, and the Netherlands, where robust neurology networks and access to molecular diagnostics have facilitated identification of genetically confirmed cases, especially those associated with DCC mutations. North American reports are largely derived from the United States and Canada, where advanced neuroimaging and neurophysiological techniques support diagnosis. Reports from South America remain limited, mostly confined to isolated case studies, likely reflecting diagnostic challenges rather than true rarity.[1,2,14,15]

Across Asia and the Middle East, both sporadic and familial cases have been reported, including genetically confirmed cases involving DCC mutations. Cultural perceptions of neurological symptoms and delayed clinical presentation may contribute to under-recognition, particularly in milder cases. In Africa, particularly in Sub-Saharan Africa (SSA), published data remain extremely scarce, largely limited to isolated case reports or small hospital-based studies. Limited availability of pediatric neurologists, neuroimaging facilities, and genetic testing contributes to underdiagnosis. There is no biological evidence to suggest lower prevalence in African populations, indicating that low reporting rates likely reflect diagnostic gaps rather than true epidemiological differences.[9,11,16,17]

Etiology and Genetics

Congenital Mirror Movements

Congenital mirror movements primarily result from genetic disruptions affecting corticospinal tract development. Several genes involved in axonal guidance and midline crossing have been implicated. Mutations in the DCC (Deleted in Colorectal Carcinoma) gene are the most frequently identified cause, accounting for approximately half of familial cases. DCC encodes a receptor for the axon guidance molecule netrin-1, which directs corticospinal axons across the midline at the pyramidal decussation. Disruption of this process leads to abnormal bilateral corticospinal projections and synchronous activation of homologous muscles during voluntary movement. [2,5,18,19]

Other genetic contributors include mutations in RAD51, a gene involved in DNA repair and neuronal development. RAD51 mutations also interfere with proper corticospinal tract organization, resulting in bilateral innervation of motor neurons. Neurophysiological studies using transcranial magnetic stimulation (TMS) often demonstrate bilateral motor-evoked potentials with symmetric latency in affected individuals, supporting abnormal corticospinal

connectivity. Despite advances in molecular genetics, a proportion of patients exhibit persistent mirror movements without identifiable mutations, suggesting the presence of additional undiscovered genetic mechanisms.[2,3,19,20]

CMM may occur in isolation or as part of syndromic conditions associated with structural developmental anomalies. Reported associations include Klippel–Feil syndrome, Kallmann syndrome, Joubert syndrome, and Moebius syndrome, as well as malformations involving the corpus callosum, brainstem, and cervicomedullary junction. These findings support the concept that abnormal corticospinal tract development and impaired interhemispheric inhibitory pathways contribute to the pathogenesis of mirror movements.[1,20]

Acquired Mirror Movements

Acquired mirror movements arise from alterations in motor system organization following neurological injury or disease. Unlike congenital forms, acquired mirror movements are often transient and may reflect compensatory neuroplastic reorganization within the motor cortex or corticospinal pathways. Neurological conditions associated with acquired mirror movements include perinatal or childhood stroke, traumatic brain injury, spinal cord injury, brain tumors, and syringomyelia.[4]

Mirror movements have also been observed in several neurodegenerative and movement disorders, including Parkinson's disease, corticobasal degeneration, Huntington's disease, and multiple system atrophy. In such conditions, impaired interhemispheric inhibition or altered motor cortical excitability may contribute to the development of mirrored motor activity. In children, mirror movements are particularly common in hemiplegic cerebral palsy, where abnormal corticospinal tract organization and compensatory cortical reorganization play important roles.[4,6,13]

Pathophysiology

Physiological Mirror Movements

Physiological mirror movements are frequently observed during early childhood and are considered part of normal motor development. These movements arise from immaturity of inhibitory circuits between the motor cortices, particularly within transcallosal pathways. During early development, incomplete suppression of ipsilateral corticospinal projections may result in the involuntary activation of homologous muscles on the contralateral side during voluntary movements.[3,21] Physiological mirror movements are typically mild, task-dependent, and gradually diminish as corticospinal pathways mature and interhemispheric inhibitory control strengthens. Neurophysiological studies using electromyography (EMG) and TMS have demonstrated that mirrored activity may originate from a single cortical source with impulses transmitted through branched corticospinal projections. Diffusion tensor imaging (DTI) studies further support this mechanism by demonstrating transient bilateral corticospinal connectivity during early development.[1,3,22]

Pathological Mirror Movements

Pathological mirror movements result from persistent abnormalities in corticospinal organization or impaired interhemispheric inhibition. Unlike physiological forms, these movements persist beyond early childhood and are typically involuntary, consistent, and non-suppressible. They often involve symmetrical activation of homologous muscles and are reproducible during voluntary motor tasks.[1] Pathological mirror movements may significantly impair fine motor coordination and bimanual tasks such as writing or object manipulation. Structural abnormalities of the corticospinal tract, defective pyramidal decussation, or reduced transcallosal inhibition have been implicated in their pathogenesis. Therefore, persistent mirror movements represent an important clinical marker of underlying neurological or developmental abnormalities and warrant further evaluation.[3]

Clinical Features and Classification

Mirror movements are defined as the involuntary activation of muscles on one side of the body that mirror intentional movements on the opposite side. They most commonly affect the hands and fingers and become particularly noticeable during tasks requiring fine motor control, such as writing, buttoning, or using utensils. In many individuals, mirror movements are present from early childhood and remain stable throughout life.[7,23] Based on age of onset, persistence, and underlying mechanism, mirror movements are broadly classified into physiological and pathological forms. Physiological mirror movements occur during early childhood and typically resolve with maturation of corticospinal pathways. In contrast, pathological mirror movements

persist beyond childhood or arise secondary to neurological disease. Clinical features of CMM typically include symmetrical mirrored movements, normal muscle tone and strength, preserved cognition, and absence of progressive neurological deficits. A positive family history may be present, although clinical severity varies widely among affected individuals.[1,23]

Diagnosis and Assessment

Diagnosis of mirror movements is primarily clinical and relies on a detailed history and focused neurological examination. Key elements include age at onset, distribution of movements, family history, perinatal events, and functional impact on daily activities. Standardized clinical rating scales have been developed to quantify the severity of mirror movements and facilitate comparison across studies.[7] The Woods and Teuber scale is one of the earliest clinical grading systems and assesses mirror movements during standardized motor tasks such as finger tapping and hand opening-closing.

The Cohen Mirror Movement Scale further refined assessment by incorporating task-specific evaluation and correlation with neurophysiological findings. Neurophysiological investigations, including EMG and TMS, provide objective evidence of bilateral corticospinal activation and impaired interhemispheric inhibition. Neuroimaging techniques such as MRI and diffusion tensor imaging are useful for identifying structural abnormalities of the corticospinal tract or associated brain malformations. Genetic testing plays an important role in confirming the diagnosis in familial cases and facilitating genetic counseling. Sequencing of DCC and RAD51 genes can identify pathogenic variants; however, such testing remains largely unavailable in many low-resource settings.[1,3,24-27]

Management and Prognosis

Management of mirror movements is primarily supportive, as no curative therapy currently exists. Treatment strategies focus on improving functional independence and minimizing the impact of mirrored movements on daily activities. Occupational and physical therapy remain the mainstays of management and may improve fine motor control and coordination through targeted rehabilitation strategies.[1,28] The prognosis of CMM is generally favorable because the condition is non-progressive and does not affect life expectancy.

Functional outcomes depend on the severity of mirrored movements and access to early rehabilitation. Surgical interventions such as corpus callosotomy were historically attempted but have largely been abandoned due to lack of benefit and potential complications. Patient education and psychosocial support remain essential components of management.[7]

Impact of Mirror Movements on Children and Adults

Although often benign, mirror movements may significantly affect daily functioning. Persistent mirrored activity can impair bimanual coordination and reduce fine motor precision, making tasks such as writing, typing, or manipulating small objects challenging. These difficulties may affect academic performance in children and occupational productivity in adults.[1] Psychosocial consequences are also important. Children with noticeable mirror movements may experience embarrassment, peer teasing, or reduced participation in sports and group activities. In addition, delayed diagnosis may lead to misinterpretation of symptoms or unnecessary investigations. Recognizing mirror movements as a potential marker of corticospinal tract abnormalities can therefore facilitate early evaluation and appropriate management.[8]

Challenges and Implications for Sub-Saharan Africa

Mirror movements present unique diagnostic challenges in Sub-Saharan Africa, where neurological services remain limited. The region faces a severe shortage of neurologists and limited access to neuroimaging and neurophysiological testing. As a result, rare conditions such as CMM are frequently overlooked within healthcare systems that prioritize more prevalent neurological disorders such as epilepsy and infectious diseases of the central nervous system. Epidemiological data on movement disorders in SSA are sparse, leading to an underestimation of disease burden and limited health system planning. Cultural beliefs and stigma surrounding neurological symptoms may further delay healthcare-seeking behavior. Persistent mirror movements may significantly impair fine motor tasks such as writing and tool manipulation, potentially affecting educational

attainment and occupational opportunities in resource-limited settings.[9,11,16,17]

Future Directions

Future research on mirror movements should focus on genotype–phenotype correlations, particularly involving DCC and RAD51 mutations, as well as mechanisms of corticospinal tract plasticity. Advances in neuroimaging and neurophysiology may provide deeper insights into abnormal motor network organization and support the development of targeted rehabilitation strategies.[2] In Sub-Saharan Africa, improving recognition and management of mirror movements will require strengthening neurological training, expanding access to diagnostic services, and integrating rare neurological disorders into national non-communicable disease strategies. Regional research collaborations and improved surveillance systems may help generate locally relevant epidemiological data and support the development of context-appropriate interventions.[9,28-30]

CONCLUSION

Congenital mirror movements represent a rare but clinically significant neurodevelopmental disorder arising from abnormal corticospinal tract organization and disrupted interhemispheric motor control. Although the condition is increasingly understood through advances in neurogenetics and neurophysiology, it remains under-recognized in many low-resource settings, particularly in Sub-Saharan Africa. This review highlights that most cases can be identified through careful clinical assessment and simple bedside evaluation, even where advanced neuroimaging or genetic testing is unavailable. Improving clinician awareness is therefore critical to preventing misdiagnosis and unnecessary investigations. Early recognition also facilitates appropriate counseling, functional rehabilitation, and monitoring for associated neurological conditions. Strengthening pediatric neurology training, expanding access to diagnostic services, and encouraging regional research will be essential to better characterize the epidemiology and clinical burden of mirror movements in Sub-Saharan Africa and to improve patient outcomes.

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