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Role of Dopamine Receptor Modulation and Emerging Therapeutic Strategies in Tardive Dyskinesia

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ABSTRACT:

Tardive dyskinesia is a chronic and potentially disabling hyperkinetic movement disorder characterized by involuntary, repetitive movements of the face, tongue, trunk, and extremities, most commonly resulting from prolonged exposure to dopamine receptor–blocking agents, particularly antipsychotic medications. The pathophysiology of TD is multifactorial, with dysregulation of dopaminergic signaling in the nigrostriatal pathway playing a central role. Chronic blockade of dopamine D_2 receptors leads to receptor upregulation and hypersensitivity, producing abnormal motor activity. Additional mechanisms such as oxidative stress, gamma-aminobutyric acid dysfunction, and genetic susceptibility have also been implicated in disease development and persistence. Epidemiological studies indicate that TD occurs in approximately 20–30% of patients receiving long-term first-generation antipsychotics, with higher risk observed in older adults, females, and individuals with underlying neurological or metabolic conditions. Diagnosis is primarily clinical and is commonly evaluated using standardized assessment tools such as the Abnormal Involuntary Movement Scale. Preventive strategies focus on minimizing exposure to dopamine receptor–blocking agents and ensuring regular monitoring of patients undergoing antipsychotic therapy. Recent therapeutic advances include vesicular monoamine transporter type 2 inhibitors, which have shown significant efficacy in reducing dyskinetic symptoms. This review discusses the clinical presentation, etiology, risk factors, the role of dopamine receptor modulation in the pathogenesis of TD, diagnosis, differential diagnosis, and and highlights emerging therapeutic strategies that may improve clinical outcomes.

Keywords: Tardive dyskinesia; Dopamine receptor modulation; Antipsychotic-induced movement disorders; VMAT2 inhibitors; Nigrostriatal pathway; Oxidative stress; Extrapyramidal symptoms.

INTRODUCTION:

Tardive dyskinesia (TD) is a delayed-onset, drug-induced movement disorder that develops primarily after prolonged exposure to dopamine receptor–blocking agents, particularly antipsychotic medications used to treat psychiatric conditions such as schizophrenia and bipolar disorder. It is characterized by involuntary, repetitive movements most commonly affecting the face, tongue, lips, trunk, and extremities, and may occasionally be accompanied by sensory symptoms such as discomfort, paresthesia, or an inner urge to move. Neuroleptic medications were introduced in the early 1950s and revolutionized the treatment of severe psychiatric disorders. However, soon after their widespread use, clinicians recognized that long-term exposure to these drugs could lead to abnormal involuntary movements. The term *tardive dyskinesia* was first introduced in 1964 by Faurbye to describe the delayed appearance of dyskinetic movements following chronic neuroleptic therapy.

Over time, the concept of TD has broadened to encompass a spectrum of tardive movement disorders, including stereotypy, akathisia, dystonia, tremor, tics, chorea, and myoclonus. While some clinicians use the term TD specifically to describe oro-bucco-lingual stereotypy, many patients present with a combination of different motor and sensory manifestations. For this reason, the broader term *tardive syndrome* is often preferred to describe the range of hyperkinetic or hypokinetic movement abnormalities that arise following exposure to dopamine receptor–blocking agents. When the disorder predominantly manifests as orofacial

movements, the term *classic tardive dyskinesia* is sometimes used. [1]

CLINICAL PRESENTATION:

Tardive dyskinesia is a chronic movement disorder characterized by repetitive, involuntary, purposeless, and irregular movements that may be continuous or intermittent in nature. These abnormal movements typically disappear during sleep, particularly during the deep phases, and their severity often fluctuates with emotional and physical states. Symptoms may worsen during periods of anxiety, excitement, or stress, while relaxation may lead to partial reduction in their intensity. Voluntary motor activity can transiently alter the expression of dyskinesia, such as during purposeful movements including finger tapping.

The disorder most commonly affects the orofacial region, presenting as grimacing, tongue protrusion or writhing, lip smacking, puckering or pursing of the lips, and excessive eye blinking. In addition to facial involvement, patients may exhibit choreiform, athetoid, or rhythmic movements of the limbs, trunk, and fingers. In severe cases, lower-limb involvement can significantly impair gait, and in rare instances may render ambulation difficult or impossible. These manifestations contrast with those observed in Parkinson's disease, in which patients experience difficulty initiating movement, whereas individuals with TD struggle to suppress involuntary motor activity.

Although less frequent, involvement of respiratory musculature has been reported and may present as grunting, irregular breathing, or difficulty in respiration; however, the prevalence of such manifestations remains relatively low. Some patients may also experience oral or genital pain as part of the clinical spectrum. Tardive dyskinesia is frequently misdiagnosed as a psychiatric condition rather than a neurological disorder, leading to inappropriate continuation or escalation of antipsychotic therapy, which can exacerbate symptoms, increase disease severity, and contribute to long-term functional impairment.

Several movement disorders are recognized as variants within the tardive spectrum. These include tardive dystonia, which resembles primary dystonia but is often persistent; tardive akathisia, characterized by intense inner restlessness and a compulsive need to move; tardive tourettism, which presents with tic-like movements similar to Tourette syndrome; and tardive myoclonus, a rare manifestation involving brief, sudden muscle jerks affecting the face, neck, trunk, or extremities. These conditions may occur independently or overlap with classical TD, complicating clinical assessment. [2,3]

ETIOLOGY:

Tardive dyskinesia was first described in the 1950s following the introduction of chlorpromazine and other antipsychotic medications. Although its precise pathophysiological mechanism remains incompletely understood, the most widely accepted explanation involves dopamine D_2 receptor supersensitivity within the nigrostriatal pathway caused by chronic dopamine receptor blockade. Antipsychotic drugs exert therapeutic effects through antagonism of D_2 receptors, and prolonged exposure is believed to induce receptor upregulation and hypersensitivity, ultimately leading to involuntary movements. This hypothesis is supported by dose–response relationships, withdrawal dyskinesias, pharmacological studies of dopamine agonists and antagonists, and evidence from animal and genetic studies. First-generation antipsychotics, which exhibit stronger D_2 receptor binding, are associated with a higher risk of TD compared with second-generation agents. However, dopamine receptor supersensitivity alone does not fully explain the delayed onset or variability of TD. Oxidative stress has been proposed as an additional mechanism; whereby increased dopamine metabolism generates reactive oxygen species that damage striatal neurons. Individual susceptibility also appears to be influenced by genetic polymorphisms, environmental exposures, and reduced neuronal reserve. Risk is increased in individuals with advanced age, intellectual disability, substance use disorders, traumatic brain injury, or cognitive impairment.

Clinical manifestations of TD may initially be masked by continued antipsychotic therapy, and symptoms often become evident only after dose reduction or discontinuation of the offending drug. Although atypical antipsychotics are generally associated with a lower risk due to weaker D_2 receptor affinity and additional serotonin receptor antagonism, they do not completely eliminate the risk. Cases have been reported with several second-generation agents, including olanzapine, risperidone, paliperidone, amisulpride, and aripiprazole, while clozapine and quetiapine appear to have the lowest propensity to induce TD.

In addition to antipsychotics, other dopamine receptor–blocking agents may contribute to TD development. The antiemetic metoclopramide is a well-recognized cause, particularly in elderly patients, while drugs such as prochlorperazine and promethazine have also been implicated. TD-like symptoms have occasionally been reported with certain antidepressants, antihistamines, antiepileptic drugs, lithium, antiparkinsonian agents, stimulants, and oral contraceptives, though these effects often resolve after dose reduction or discontinuation. [4]

RISK FACTORS:

The risk of developing tardive dyskinesia is influenced by a combination of demographic, clinical, pharmacological, and genetic factors. Several studies have reported an increased risk of TD among individuals who smoke, with evidence suggesting a dose-dependent relationship between cigarette smoke exposure and the development of dyskinetic movements in patients receiving antipsychotic therapy, although conflicting findings have also been reported. Advancing age represents one of the most consistently identified risk factors, with elderly individuals demonstrating increased vulnerability, likely due to reduced neuronal reserve and altered drug metabolism.

Female sex has been associated with a higher incidence of TD, particularly among older women, and patients with comorbid medical or neurological conditions are at increased risk. These include individuals with organic brain injury, diabetes mellitus, and those exhibiting prominent negative symptoms of schizophrenia. Additionally, TD appears more frequently in patients who experience acute extrapyramidal or other neurological adverse effects during antipsychotic treatment, suggesting shared vulnerability mechanisms. Incidence rates in postmenopausal women have been reported to reach up to 30% after approximately one year of antipsychotic exposure, suggesting a possible protective role of estrogen through modulation of dopamine-mediated pathways and antioxidant mechanisms.

Racial differences in TD prevalence have been observed, with higher rates reported among individuals of African or African American ancestry following exposure to antipsychotic medications. Genetic susceptibility also plays an important role, as polymorphisms in genes encoding dopamine and serotonin receptors—particularly the dopamine D_3 receptor and serotonin 5-HT_2A and 5-HT_2C receptors—have been implicated in increased risk. Collectively, these factors underscore the multifactorial nature of TD risk and highlight the importance of individualized risk assessment and vigilant monitoring in patients receiving long-term antipsychotic therapy. [5,6]

PATHOPHYSIOLOGY:

Tardive dyskinesia is a chronic hyperkinetic movement disorder characterized by involuntary, repetitive movements predominantly affecting the orofacial musculature, trunk, and extremities. It most commonly develops after prolonged exposure to dopamine receptor–blocking agents, particularly antipsychotic medications, although similar dyskinetic phenomena have been observed in antipsychotic-naïve individuals with schizophrenia and other neuropsychiatric disorders. These observations suggest that TD arises from a complex interaction between pharmacological dopamine blockade, intrinsic disease-related neurobiological vulnerability, and individual genetic susceptibility. Despite decades of research, the precise pathophysiology of TD remains incompletely understood; however, converging evidence strongly implicates dysregulation of dopaminergic

neurotransmission within the basal ganglia as the central mechanism.

The dopamine hypersensitivity hypothesis is the most widely accepted and extensively studied explanation for the development of TD. According to this hypothesis, chronic antagonism of dopamine D_2 receptors in the nigrostriatal pathway leads to compensatory upregulation of postsynaptic dopamine receptors in the striatum. Antipsychotic medications exert their therapeutic effects primarily through blockade of D_2 receptors, reducing dopaminergic transmission and alleviating psychotic symptoms. In response to sustained receptor blockade, the brain attempts to restore dopaminergic signaling by increasing D_2 receptor density and sensitivity. Over time, this adaptive response results in a state of dopamine supersensitivity, such that even normal or reduced levels of dopamine produce exaggerated postsynaptic responses, manifesting clinically as involuntary hyperkinetic movements.

The basal ganglia play a crucial role in the regulation of voluntary movement through the coordinated activity of the direct and indirect motor pathways. Dopamine normally facilitates movement by stimulating the direct pathway via D_1 receptors and inhibiting the indirect pathway via D_2 receptors. Chronic D_2 receptor blockade disrupts this balance, initially suppressing movement. With prolonged exposure, however, receptor upregulation leads to downregulation of the indirect pathway, reducing inhibitory control over thalamocortical motor output. This disinhibition of motor circuits results in excessive and poorly regulated movement, which is a hallmark of TD. The predilection of TD for orofacial musculature is thought to reflect the dense representation of these muscle groups within the striatum.

Several clinical observations provide strong support for the dopamine hypersensitivity hypothesis. First, increasing the dose of antipsychotic medication often leads to transient improvement or masking of TD symptoms, presumably by restoring receptor blockade. However, this effect is temporary, and symptoms typically re-emerge or worsen with continued exposure. Second, first-generation antipsychotics, which produce stronger and more sustained D_2 receptor blockade, are associated with a significantly higher risk of TD than second-generation agents. Third, withdrawal or dose reduction of antipsychotics frequently results in exacerbation of dyskinetic movements, consistent with unopposed stimulation of supersensitive dopamine receptors. Finally, the clinical efficacy of vesicular monoamine transporter type 2 (VMAT2) inhibitors, which reduce presynaptic dopamine release, provides indirect but compelling evidence for the central role of dopamine excess in TD pathogenesis.

Genetic studies further reinforce the importance of dopaminergic mechanisms in TD. Polymorphisms in dopamine receptor genes, particularly those encoding D_2 and D_3 receptors, have been associated with increased susceptibility to TD in multiple populations. These genetic variations may influence receptor density, binding affinity, or intracellular signaling, thereby modulating an individual's response to chronic dopamine antagonism. Polymorphisms affecting dopamine metabolism and handling, including those involving VMAT2 and dopamine transporter–related genes, have also been implicated, although findings in this area have been less consistent. Such genetic factors may explain why TD develops in some patients but not others, even with similar drug exposure and duration of treatment.

While dopamine receptor hypersensitivity provides a robust framework for understanding TD, it does not fully account for certain clinical features, particularly the persistence or irreversibility of symptoms after discontinuation of the offending drug. This limitation has led to the exploration of additional contributory mechanisms that may act synergistically with dopaminergic dysfunction. Among these, abnormalities in gamma-aminobutyric acid (GABA) neurotransmission have received significant attention. GABAergic interneurons in the striatum exert inhibitory control over motor output and play a critical role in maintaining balance between the direct and indirect basal ganglia pathways. Chronic dopamine blockade may lead to dysfunction or degeneration of these GABAergic neurons, resulting in impaired inhibitory modulation

and further amplification of motor hyperactivity. Experimental studies have demonstrated that long-term exposure to antipsychotic medications can reduce GABA synthesis and release within the basal ganglia. Damage to parvalbumin-positive fast-spiking interneurons, which are essential for synchronizing striatal output, may disrupt the fine-tuning of motor signals. Although this hypothesis is supported by neurobiological evidence, clinical trials using GABA agonists or GABA-enhancing agents have generally produced modest or inconsistent benefits, suggesting that GABA dysfunction alone is unlikely to be the primary driver of TD but may contribute to its severity and persistence.

Another important mechanism implicated in TD pathophysiology is oxidative stress**.** Dopamine metabolism inherently generates reactive oxygen species, including hydrogen peroxide and free radicals, which can cause neuronal damage if not adequately neutralized by antioxidant systems. Chronic dopamine receptor blockade leads to increased dopamine synthesis and turnover, thereby amplifying oxidative by-product generation. Over time, excessive oxidative stress may damage neuronal membranes, mitochondria, and intracellular signaling pathways, particularly within the striatum, which is rich in dopamine terminals. Both preclinical and clinical studies have demonstrated elevated markers of oxidative stress in patients receiving long-term antipsychotic therapy. Increased lipid peroxidation, altered antioxidant enzyme activity, and accumulation of transition metals such as iron and manganese within the basal ganglia have all been reported. These changes may compromise neuronal integrity and plasticity, contributing to the structural and functional alterations that underlie persistent dyskinetic movements. Oxidative injury may therefore represent a key mechanism explaining why TD can become irreversible in some patients, even after withdrawal of dopamine antagonists.

Importantly, these proposed mechanisms—dopamine hypersensitivity, GABAergic dysfunction, and oxidative stress—are not mutually exclusive. Rather, they likely interact in a cumulative and self-reinforcing manner. Dopamine receptor upregulation may increase neuronal excitability and metabolic demand, thereby enhancing oxidative stress, which in turn may damage inhibitory GABAergic circuits and further exacerbate dopaminergic imbalance. This interplay may account for the progressive nature of TD and its variable clinical course.

An additional layer of complexity is introduced by evidence suggesting that TD may, in part, reflect an intrinsic motor vulnerability associated with schizophrenia itself. Dyskinetic movements have been observed in antipsychotic-naïve patients with schizophrenia, as well as in unaffected first-degree relatives, indicating a possible genetic or neurodevelopmental predisposition. Neuroimaging and neurophysiological studies have identified abnormalities in basal ganglia structure and function in schizophrenia independent of medication exposure. These findings suggest that antipsychotics may unmask or amplify pre-existing motor circuit abnormalities rather than acting as the sole cause of TD. [7,8]

DIAGNOSIS:

The diagnosis of tardive dyskinesia is primarily clinical and is established through careful observation of spontaneous involuntary movements, particularly involving the face and orofacial musculature. These movements are typically present at rest and may partially diminish during voluntary motor activity, such as when the patient is asked to protrude the tongue. Diagnosis requires evaluation of the pattern, distribution, persistence, and temporal relationship of abnormal movements to prior exposure to dopamine receptor–blocking agents. Several standardized rating scales are used to assess the presence and severity of TD. The Abnormal Involuntary Movement Scale (AIMS) is the most widely used tool in both clinical practice and research. It is recommended to perform the AIMS assessment at baseline before initiating antipsychotic therapy and periodically thereafter, usually every three months. The scale consists of 12 items that evaluate involuntary movements in various body regions, as well as the severity of dyskinesia,

functional impairment, and patient awareness of abnormal movements. According to the Schooler–Kane criteria, a probable diagnosis of TD is indicated by an AIMS score of at least 2 in two or more body regions or a score of 3–4 in one region in patients with at least three months of antipsychotic exposure.

In general, antipsychotic-induced TD is diagnosed when involuntary movements persist for at least one month after exposure to neuroleptic medications for a minimum of three months, or one month in individuals aged 60 years or older. It is important to distinguish TD from withdrawal dyskinesias, which occur shortly after discontinuation of antipsychotics and typically resolve spontaneously. Other acute extrapyramidal syndromes should also be excluded. When TD occurs in patients with cognitive impairment or dementia, alternative neurological conditions such as Huntington disease, Wilson disease, or central nervous system tumors should be considered. Neuroimaging studies, including computed tomography or magnetic resonance imaging, are generally normal in TD but may be useful in excluding other disorders, such as caudate nucleus atrophy in Huntington disease or basal ganglia calcification in Fahr syndrome. Additional rating scales, such as the Extrapyramidal Symptoms Rating Scale and the Simpson Rating Scale, may also be used to evaluate drug-induced movement disorders, though AIMS remains the most commonly applied instrument for monitoring TD severity and progression. [9,10]

DIFFERENTIAL DIAGNOSIS:

Tardive dyskinesia must be differentiated from a range of neurological and movement disorders that present with involuntary movements. Chorea associated with conditions such as Huntington's disease, Sydenham chorea, chorea gravidarum, cerebral palsy, and Wilson disease should be considered, particularly when there is a genetic, metabolic, or autoimmune background. Tic disorders, including Tourette syndrome, differ from TD in that movements are often suppressible and preceded by a premonitory urge, with onset typically in childhood.

Essential tremor may mimic TD but is characterized by rhythmic, action-induced oscillations rather than irregular choreiform movements. Epileptic conditions, including focal impaired-awareness seizures, frontal lobe epilepsy, juvenile myoclonic epilepsy, and epilepsia partialis continua, should be excluded when abnormal movements are episodic or associated with altered consciousness. Dystonia and neurodegenerative disorders such as corticobasal syndrome present with sustained postures, rigidity, or apraxia, features that distinguish them from TD. [11]

PREVENTION AND MANAGEMENT:

Prevention and management of tardive dyskinesia primarily focus on minimizing exposure to dopamine receptor–blocking agents while ensuring adequate control of the underlying psychiatric condition. Prevention relies on the judicious use of antipsychotic medications, employing the lowest effective dose for the shortest possible duration. In chronic psychiatric disorders such as schizophrenia, this approach must be balanced against the need to prevent relapse of psychosis. Regular reassessment of the necessity of antipsychotic therapy is essential, and patients receiving long-term treatment should undergo periodic monitoring using standardized tools such as the Abnormal Involuntary Movement Scale. When TD is suspected or identified, reduction or discontinuation of the offending drug should be considered whenever clinically feasible, although symptoms may persist for months, years, or even permanently after withdrawal.

Switching from first-generation antipsychotics to second-generation (atypical) antipsychotics is commonly recommended, as these agents generally carry a lower risk of TD due to weaker dopamine D_2 receptor affinity and additional serotonergic activity. Among atypical antipsychotics, clozapine and quetiapine are considered to have the lowest propensity to induce or worsen TD. Adjunctive preventive approaches have also been explored, including the use of antioxidants such as vitamin E, melatonin, and other high-dose vitamins based on the hypothesis that oxidative stress contributes to TD

pathogenesis. However, current evidence supporting these strategies remains limited and inconsistent, and routine prophylactic use is not yet recommended. Importantly, the prophylactic administration of antiparkinsonian agents alongside antipsychotics has not been shown to prevent TD and may increase susceptibility to the disorder.

Management of established TD requires careful reassessment of ongoing dopamine antagonist therapy. Gradual dose reduction or withdrawal of the causative drug may be beneficial, although abrupt discontinuation should be avoided because it may precipitate rebound psychosis or transient worsening of dyskinetic movements. When continued antipsychotic treatment is necessary, switching to an atypical agent—particularly clozapine—may help reduce symptom severity while maintaining psychiatric stability.

Pharmacological treatment options have expanded with the approval of vesicular monoamine transporter type 2 (VMAT2) inhibitors**.** Valbenazine, approved by the US FDA in 2017, and deutetrabenazine, approved shortly thereafter, have demonstrated significant improvement in involuntary movements as measured by the Abnormal Involuntary Movement Scale in randomized, placebo-controlled trials. These agents reduce presynaptic dopamine release and are currently regarded as first-line treatments for moderate to severe TD. Tetrabenazine, another dopamine-depleting agent, has also been used, though its adverse effect profile limits widespread use.

Other pharmacological agents have shown variable or limited efficacy. Clonazepam and ginkgo biloba are recommended by evidence-based guidelines of the American Academy of Neurology, while vitamin B_6 and vitamin E have shown modest benefits in small clinical trials, though overall evidence remains weak. Clonidine may provide symptomatic relief but is limited by hypotension and sedation. Botulinum toxin injections can be beneficial in focal tardive dystonia, such as blepharospasm, but are not effective for generalized TD. Current evidence does not support routine use of benzodiazepines, baclofen, antiepileptic drugs, calcium channel blockers, or sodium valproate.

In treatment-resistant cases, deep brain stimulation of the globus pallidus internus has shown promising results in reducing motor symptoms without significant psychiatric deterioration, although this intervention is reserved for severe, refractory TD. Surgical lesioning procedures are rarely considered due to limited evidence and potential risks. Throughout management, clinicians should obtain informed consent, regularly reassess treatment necessity, and avoid inappropriate pharmacologic or surgical interventions in patients with psychogenic movement disorders. Overall, while effective symptomatic treatments are now available, primary prevention and early intervention remain the most effective strategies, as TD may persist despite optimal therapy. [12,13]

EPIDEMIOLOGY:

Tardive dyskinesia occurs most commonly in individuals with psychiatric disorders who receive long-term treatment with antipsychotic medications. The overall prevalence of TD has been estimated to be approximately 20–30% among patients exposed to first-generation antipsychotics, with risk increasing progressively with duration of treatment. Longitudinal studies suggest that approximately one-third of patients develop persistent dyskinetic movements after five years of continuous antipsychotic use, with prevalence rising substantially after prolonged exposure extending beyond 10–15 years. In older populations, particularly those aged 45 years and above, TD has been reported to develop in nearly one-quarter of patients within the first year of treatment, with cumulative incidence increasing markedly over subsequent years, indicating that long-term exposure represents the most significant epidemiological determinant.

Race and ethnicity appear to influence TD prevalence, with several studies reporting higher rates among individuals of African or African American ancestry following long-term exposure to dopamine receptor–blocking agents compared with individuals of European descent. Conversely, studies

involving Asian populations, including Filipino cohorts, have demonstrated comparatively lower prevalence rates despite continued use of first-generation antipsychotics, highlighting the potential contribution of genetic and environmental factors. The duration of antipsychotic exposure remains a consistent predictor across racial groups, with longer treatment associated with higher prevalence.

The type of antipsychotic medication plays a critical role in TD epidemiology. First-generation antipsychotics are associated with a substantially higher incidence of TD compared with second-generation agents. Annual incidence rates are estimated at approximately 2–5%, with cumulative prevalence ranging from 15–30% among individuals receiving long-term antipsychotic therapy. Comparative studies indicate that typical antipsychotics are associated with prevalence rates exceeding 30%, whereas atypical antipsychotics demonstrate lower rates, generally ranging between 10–15%. Nonetheless, although second-generation antipsychotics have reduced the overall burden of TD, the decline has been less pronounced than initially anticipated, underscoring that these agents do not eliminate risk entirely. [14,15]

PROGNOSIS:

Tardive dyskinesia is generally considered a chronic disorder with a variable clinical course. Although it was previously regarded as irreversible, longitudinal studies suggest that symptoms may fluctuate and occasionally improve after reduction or discontinuation of the causative medication. Prognosis is influenced by factors such as prolonged neuroleptic exposure, presence of affective disorders, and poor treatment response in chronic psychotic patients. Most cases are mild to moderate, while severe dyskinesia with significant functional impairment is relatively uncommon. Although current treatments may reduce symptom severity, complete resolution remains rare, emphasizing the importance of early detection and prevention. [16]

CONCLUSION:

Tardive dyskinesia remains a significant complication of long-term dopamine receptor–blocking therapy, and improved understanding of its pathophysiology and emerging targeted treatments is essential for early detection, effective management, and better patient outcomes.

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