

Emerging Pharmacological Approaches in Peripheral Neuropathy: Current Perspectives and Future Directions

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Peripheral neuropathy is a broad and clinically diverse group of disorders affecting the peripheral nervous system. Patients may experience pain, numbness, tingling, weakness, impaired balance, and progressive difficulties with daily activities. Diabetes is one of the most common causes, but peripheral neuropathy may also result from inherited disorders, nutritional deficiencies, infections, autoimmune conditions, medications, toxins, and metabolic abnormalities. This diversity makes effective treatment a continuing challenge.

From a pharmaceutical perspective, the management of peripheral neuropathy has traditionally focused on controlling symptoms, particularly neuropathic pain. Drugs such as duloxetine, pregabalin, gabapentin, and tricyclic antidepressants remain widely used therapeutic options. Topical agents, including lidocaine and high-concentration capsaicin, can also be useful for selected patients. Although these treatments can provide meaningful symptom relief, their effectiveness varies between individuals and adverse effects may limit their use.

An important limitation of current treatment is that pain reduction does not necessarily mean that the underlying nerve damage has been prevented or reversed. This has encouraged researchers to investigate therapies that target the biological mechanisms responsible for peripheral nerve injury. Oxidative stress, mitochondrial dysfunction, neuroinflammation, abnormal ion-channel activity, impaired axonal transport, and Schwann-cell dysfunction are among the mechanisms receiving increasing attention.

Hereditary neuropathies provide an especially interesting opportunity for mechanism-based therapeutic development. Advances in genetic testing have identified numerous genes associated with inherited peripheral neuropathies, including PMP22, MPZ, MFN2, and GJB1. As the molecular basis of these disorders becomes clearer, treatment strategies can increasingly be designed around individual genetic defects rather than relying exclusively on symptomatic management.

Gene-based therapies represent one of the most promising developments in this area. Researchers are investigating gene replacement, gene silencing, RNA-based approaches, and gene-editing technologies for several inherited neuropathies. CMTX1, caused by pathogenic variants in GJB1, is an important example in which researchers are investigating approaches designed to restore connexin-32 function in Schwann cells. Although these approaches remain under development, they represent a

significant shift toward treating the underlying cause of disease.

Drug-delivery technology is another important area of pharmaceutical research. Delivering therapeutic molecules or genetic material to peripheral nerves and Schwann cells in sufficient concentrations remains challenging. Nanoparticles, viral vectors, lipid-based systems, and other targeted delivery technologies may help overcome some of these limitations. For pharmaceutical scientists, the combination of formulation science, molecular biology, pharmacology, and targeted delivery provides considerable opportunities for translational research.

The future of peripheral neuropathy treatment will also depend on better biomarkers and outcome measures. Many neuropathies progress slowly, making it difficult to determine whether a treatment is genuinely modifying disease progression. Improved electrophysiological measures, imaging techniques, molecular biomarkers, functional assessments, and patient-reported outcomes could help researchers evaluate emerging therapies more effectively.

Precision medicine may ultimately become an important component of peripheral neuropathy management. Genetic information, clinical characteristics, disease mechanisms, and individual treatment responses could be integrated to select therapies more effectively. Such an approach may be particularly valuable for rare hereditary neuropathies, where conventional “one-treatment-fits-all” strategies are unlikely to be sufficient.

Despite these advances, considerable challenges remain. Many promising therapies are still at the preclinical or early clinical stage, and questions regarding long-term safety, delivery, manufacturing, cost, and accessibility must be addressed. Translation from successful animal studies to effective human treatments also remains a major hurdle.

Nevertheless, the field is moving beyond an approach based solely on symptom control. The combination of pharmacological innovation, genetic medicine, advanced drug-delivery systems, and precision therapeutics offers a realistic opportunity to develop treatments capable of preserving nerve function and slowing disease progression.

For pharmaceutical researchers, peripheral neuropathy represents an important area in which basic science can be translated into meaningful therapeutic advances. Continued collaboration among pharmacologists, neurologists, geneticists, formulation scientists, and clinical researchers will be essential to transform promising laboratory discoveries into safe, effective, and accessible treatments for patients with peripheral neuropathy.