microbiota of a healthy donor into a PD patient. Preclinical and early clinical studies have shown that FMT can correct intestinal ecological imbalance in PD models, alleviate intestinal and central nervous system inflammation, and improve gastrointestinal and partial motor symptoms (Guo et al., 2025; Porwolik et al., 2025). Mechanism studies have shown that FMT can inhibit pro-inflammatory signaling pathways such as TLR4/NF-κB, repair the integrity of the intestinal and blood-brain barriers, and reduce the aggregation of α -synuclein in the intestinal and central nervous systems, thereby exerting neuroprotective effects (Zhao et al., 2021; Panaitescu et al., 2024). However, its exact mechanism of action and long-term safety still await further systematic assessment.

In addition to fecal microbiota transplantation, anti-inflammatory measures targeting the intestine and methods for repairing the intestinal barrier are also being intensively studied, including specific probiotics, prebiotics, nutritional supplements with anti-inflammatory effects, and intervention measures that can enhance the function of the intestinal mucosal barrier (Wang et al., 2021; Yao et al., 2024; Kumar et al., 2025). These methods can reduce intestinal permeability, that is, solve the problem of "leaky gut", and also alleviate the inflammatory response throughout the body. They are expected to sever the pathological link between abnormal intestinal function and neurodegeneration in patients with Parkinson's disease. Although these methods have promising prospects, they are still in the early stage of clinical application at present. Therefore, it is necessary to formulate standardized treatment procedures and comprehensively assess their safety and practical effects.

6.3 Vagus nerve regulation, combined DBS strategy and comprehensive management model for intestinal health

The vagus nerve is an important signaling channel on the gut-brain axis, responsible for transmitting various neural and immune signals between the intestine and the central nervous system. Regulating the activity of the vagus nerve by methods such as drugs, electrical stimulation or behavioral intervention is believed to affect the neuroinflammation of PD and the transmission process of α-synuclein (Wang et al., 2021). At present, vagus nerve stimulation (VNS) and related neuromodulation techniques are being studied for alleviating neuroinflammation, improving gastrointestinal peristalsis, and possibly even delaying disease progression. However, the relevant clinical research is still in its infancy (Yadav and Raj, 2025).

On this basis, incorporating intestinal health management into the PD care system has also attracted increasing attention. For example, combining deep brain stimulation (DBS) with intestinal-targeted therapy, dietary guidance, and regular examination of gastrointestinal symptoms, and jointly improving patients' motor and non-motor symptoms through multiple methods (Salim et al., 2022; Zhu et al., 2022). With the continuous deepening of research, personalized comprehensive management plans centered on gugut brain axis intervention and combined with existing neuromodulation therapies are expected to become an important way to improve the rehabilitation effect of PD patients (Wang et al., 2021; Alam et al., 2024; Kumar et al., 2025).

7 Conclusion

The gut-brain axis for Parkinson's disease (PD) offers promising approaches for disease improvement and enhancing the quality of life of patients. Interventions such as probiotics, prebiotics, dietary adjustments, and fecal microbiota transplantation (FMT) can, to a certain extent, regulate intestinal ecological imbalance, reduce neuroinflammation, and improve both motor and non-motor symptoms. At the same time, they partially act on potential pathogenic mechanisms such as abnormal intestinal permeability and α-synuclein aggregation. Therefore, integrating intestinal-directed therapy into PD management It is expected to achieve a transformation from simple symptom relief to more comprehensive disease improvement.

The microbiota in the gut can change due to factors such as genetics, environment, and diet, making it difficult to establish a universal treatment approach and biomarkers. There are currently no unified usage norms for intervention methods such as fecal microbiota transplantation (FMT), probiotic regulation, and dietary adjustment, which affects the comparability and consistency of research results. At present, the basis of related research mostly comes from animal experiments or small-scale human studies, and there is still a lack of large-scale, scientifically designed clinical trials to confirm the efficacy and safety of these methods for different patients. Therefore, we urgently need more rigorous clinical research and more targeted treatment plans to enhance the therapeutic effect.