MEGA JOURNAL OF CASE REPORTS

OPEN ACCESS

Editorial

Compiled Date: May 21, 2025

Editorial

Peptide Therapy: The Future of Medicine

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Peptides are a misunderstood supplement within the medical community primarily because the information available is based on animal studies, FDA Phase 3 trials, or anecdotal evidence. Peptides and proteins are polymers of amino acids. Generally, polymers having less than 100 amino acids are known as peptides [1]; those with 100 or more are known as proteins. Peptides are formed from protein breakdown, and their structure and function are determined by the sequence and spatial arrangement of amino acids within them.

Therapeutic peptides, typically consisting of 20 to 50 amino acids and weighing 500-5000 Da [2], have evolved significantly since the isolation of insulin in 1921, marking the inception of peptide- based drugs. This initial breakthrough paved the way for over 80 approved peptide drugs worldwide, particularly in response to the high demand for insulin and the advancements in peptide synthesis and purification technologies. The scope of therapeutic peptides has expanded beyond their natural origins. Synthetic analogs mimic the therapeutic effects of endogenous peptides [3], like Enfuvirtide, Ziconotide, and Liraglutide, which target various medical conditions including diabetes, chronic pain, and HIV. Peptides play key roles in diagnosis, drug discovery, and immunology, among other fields [2,4,5]. They function as hormones and neurotransmitters, bind to cell surfaces, and trigger intracellular signals with high affinity and specificity while maintaining low immunogenicity [6-8]. The FDA has granted approvals for approximately 102 therapeutic peptides across various applications as therapeutic drugs [3], complemented by an additional 260 that have undergone testing in human clinical trials [9].

Peptide drugs have become a major segment of the pharmaceutical market, reaching over $70 billion in global sales in 2019 [10], more than doubling figures from 2013 [11]. Among the top 200 drug sales in 2019 [12], there were 10 non-insulin peptide drugs, with GLP-1 analogues for Type 2 Diabetes Mellitus dominating the market. The leading sales were Trulicity (dulaglutide) at $4.39 billion, followed by Victoza (liraglutide) at $3.29 billion, and Rybelsus (semaglutide) at $1.68 billion, highlighting the rising importance of peptide therapeutics in treating chronic disorders [2].

Key Areas of Peptide Therapy Research

Oncology [4-9]

Peptides can be applied (used) in tumor therapy in four main (primary) ways: [13-15] 1) using radioisotopes, dyes, or other reported molecular-labeled peptides as probes for tumor diagnosis and imaging; 2) using peptide-coupled nanomaterials for tumor therapy; 3) using peptide vaccines to activate the immune system for prevention; and 4) using peptides alone as targeted drugs.

Peptide-based imaging probes selectively bind to receptors expressed in tumors. These receptors can be located on the cell surface (e.g., αvβ3 integrin [RGD peptide], EGF receptor, somatostatin receptor, neurotensin receptor, transferrin receptor), intracellularly (e.g., Bcr/Abl, cyclin A, cyclin kinase), or in the extracellular matrix (e.g., fibronectin, matrix metalloproteinases, prostate-specific antigen). The distribution of these probes can be visualized using single photon emission computed tomography/computed tomography (SPECT/CT) scanning, aiding early tumor diagnosis and surgical planning.

Several radiolabeled peptide probes, such as Octreoscan and Depreotide—both somatostatin analogs—have been FDA-approved for imaging neuroendocrine tumors and lung cancer [16,17]. Beyond imaging, internal radiotherapy follows the same principle, with β-emitting isotopes conjugated to peptides. However, this approach is limited by radiation damage to normal tissues expressing the same target receptors. Examples include AN-152 and AN-207, Luteinizing Hormone-Releasing Hormone (LHRH) analogs linked to adriamycin, which have demonstrated anticancer activity in LHRH receptor-positive tumors. Phase I and II trials indicate their effectiveness in treating breast, endometrial, and ovarian cancers, with moderate toxicity [18]. Despite promising preclinical and clinical results, only two peptide-based drugs are currently FDA-approved for cancer treatment: mifamurtide for osteosarcoma and carfilzomib for multiple myeloma. Ongoing research continues to explore therapeutic peptides for common malignancies, such as lung and gastric cancer [2].

Peptide-based imaging probes target specific receptors associated with tumors, allowing for precise visualization of tumor distribution using Single-Photon Emission Computed Tomography/ Computed Tomography (SPECT/CT). These probes bind to receptors found on tumor cell surfaces—like the αvβ3 integrin and EGF receptor—or in the extracellular matrix, facilitating early diagnosis and aiding surgical decisions [13]. Notably, FDA-approved probes such as octreoscan and depreotide utilize radiolabeled somatostatin-like peptides for effective imaging of neuroendocrine tumors and lung cancer.

Antiviral Peptides

Antiviral peptides are gaining attention due to their high specificity and effectiveness in targeting viruses. These peptides work by blocking viral infection, as seen with drugs like enfuvirtide (for HIV) and boceprevir/telaprevir (for HCV). Several antiviral peptides are in clinical trials for diseases such as hepatitis B, influenza, and HIV-1.

The COVID-19 pandemic accelerated research into antiviral peptides, particularly for vaccine development. Scientists rapidly sequenced the SARS-CoV-2 genome and explored peptide-based vaccines, which offer advantages like high specificity and safety. Research groups have used immunoinformatics and epitope-based design to identify potential vaccine candidates targeting the virus's spike protein [2].

Although no peptide vaccines for COVID-19 have been approved, this research has significantly advanced the field, providing valuable insight for developing future antiviral peptides against emerging viruses.

Metabolic Disorders [19]

Maintaining metabolic homeostasis is essential for overall health, as it regulates various biological pathways. Disruptions in metabolic balance can lead to chronic metabolic diseases, which develop gradually and have complex causes. These conditions affect approximately 35% of adults and 50% of the aging population. The most common metabolic diseases include obesity, diabetes, non-alcoholic fatty liver disease, and cardiovascular disease [20].

Peptide-Based Treatments for Obesity and Diabetes

Currently, the obesity drug market is dominated by two peptide-based medications: liraglutide (marketed as Saxenda and Victoza) and semaglutide (marketed as Rybelsus and Ozempic) [20]. Liraglutide is a Glucagon-Like Peptide-1 (GLP-1) receptor agonist. It increases insulin secretion, reduces glucagon release, and suppresses appetite. Clinically, Victoza is used to manage diabetes, while Saxenda is prescribed for weight loss in obese patients. Studies show that incorporating liraglutide into lifestyle interventions leads to an average weight loss of 4–6 kg within one year [21]. Semaglutide functions similarly to liraglutide, promoting weight loss and stabilizing blood sugar levels.

Other Peptide-Based Treatments in Metabolic and Cardiovascular Health

Motixafortide (Aphexda) is a chemokine antagonist approved for cardiovascular conditions, including hypertension. Natriuretic peptides regulate blood pressure and fluid balance. Dysregulation of these peptides is linked to obesity, glucose intolerance, type 2 diabetes, and cardiovascular diseases such as atherosclerosis and myocardial ischemia.

Peptides for Osteoporosis (OP) Treatment

Salmon calcitonin, Teriparatide and Abaloparatide are available for osteoporosis treatment.

These peptides help improve bone health and are used in osteoporosis management [22].

Neurodegenerative Diseases [23]

Peptide therapy research holds promise for advancing treatments for neurodegenerative diseases characterized by progressive neuron loss, such as Alzheimer's, Parkinson's, Huntington's, and ALS, which account for a significant portion of global mortality and disability. By exploring the role of misfolded proteins and disrupted neuronal signaling, researchers are investigating peptide vaccines such as UB-311 that show potential in enhancing cognition in early Alzheimer's patients, along with various peptide inhibitors such as neurotrophins, NAPVSIPQ, and

Vasoactive Intestinal Peptides (VIP) that could offer new therapeutic avenues in managing the above mentioned or many debilitating disorders.

Regenerative Medicine [24]

Peptides are revolutionizing how we approach healing and recovery. Unlike traditional treatments that only manage symptoms, peptide treatments work at the cellular level to enhance tissue repair, minimize inflammation, and optimize the body's natural recovery process. Whether you're dealing with muscle tears, joint injuries, post-surgical wounds, or chronic pain, peptides provide a powerful, science-backed solution to heal faster, reduce pain, and improve overall tissue function [24].

Many therapeutic peptides are gaining attention, including BPC 157, TB500, GHK-CU, CJC 1295, Ipamorelin, Sermorelin, MK 677. Epitalin and SS31 for their potential to enhance performance, recovery, and tissue repair; although more human-centric studies are needed to clarify their mechanisms. The increasing interest in peptides such as BPC157, TB500, CJC 1295, and Ipamorelin for injury repair highlights their potential benefits in musculoskeletal and soft tissue healing through localized or subcutaneous administration. BPC 157 has shown promising healing properties in animal studies, particularly for musculoskeletal injuries such as those affecting tendons, ligaments, and skeletal muscles. It does so by promoting cell survival, migration, and angiogenesis. Its efficacy extends to both traumatic and systemic injuries, enhancing wound closure and collagen deposition [25,26]. With a favorable safety profile and stability in human gastric juice, BPC 157 suggests potential for safe application in humans.

What do peptides do?

- Boost collagen & elastin production: Strengthens skin, joints, tendons, and ligaments.
- Reduce inflammation & oxidative stress: Lowers TNF-alpha and IL-6 to prevent excessive swelling.
- Promote angiogenesis: Creates new blood vessels to improve oxygen & nutrient delivery to damaged tissues.
- Accelerate wound healing & reduce scarring: Supports proper tissue repair while preventing fibrosis.
- Enhance immune modulation: Prevents overactive inflammation while optimizing the body's natural healing response.

The peptides that are transforming pain management and overall wellness:

- BPC-157: Accelerates healing of muscles, tendons, and ligaments, reduces inflammation, and supports gut health.
- TB-500: Promotes tissue regeneration, improves muscle recovery and joint mobility, and aids in wound healing.
- GHK-Cu: Stimulates collagen production for firmer skin, reduces wrinkles, strengthens hair, and supports tissue repair.
- CJC-1295: stimulate the release of GH and IGF-1, hormones crucial for growth, metabolism, and tissue repair.

These peptides offer a promising new frontier in healthcare, providing natural and effective support for pain relief, recovery, and anti-aging.

BPC-157: The Injury Repair Peptide- known as the body protection compound, helps accelerate healing and reduce inflammation.

- Speeds up muscle, tendon and ligament repair.

- Eases joint pain by reducing swelling and inflammation.
- Supports gut health, improving recovery from digestive issues.

This peptide is popular among athletes (but good for everyone) recovering from injuries and anyone dealing with chronic joint or muscle pain.

TB-500 (TB4): Muscle and Tissue Recovery- well known for promoting tissue regeneration and keeping the body flexible.

- Increases muscle recovery after workouts or injuries.
- Helps with joint mobility by reducing muscle tightness.
- Improves wound healing and aids in soft tissue repair.

This peptide is ideal for anyone looking to recover quickly, stay active or improve flexibility.

GHK-CU: The Anti-aging + Skin Peptide- GHK-CU (Copper Peptide) promotes collagen production and has a range of skin and tissue benefits.

- Stimulates collagen for firmer, more elastic skin.
- Reduces wrinkles and fine lines for a youthful appearance.
- Strengthens hair follicles and encourages healthy growth.
- A support wound healing and minimizes scarring.

GHK-CU peptide is not just for aesthetics. It supports tissue repair and healing throughout the body.

CJC-1295: long-acting analog of Growth Hormone-Releasing Hormone (GHRH), associated with increased plasma Growth Hormone (GH) and Insulin-like Growth Factor 1 (IGF-1) levels,

- Increased lean muscle mass, fat loss, and improved healing and recovery.

How They Work Together? – These peptides complement each other to support your body's recovery and well being.

- BPC-157: reduces inflammation and repairs tissues.
- TB-500: promotes flexibility and speeds up muscle recovery.
- GHK-CU: enhances skin, hair and tissue health. Together, they create a well-rounded approach to healing, performance and anti-aging.

While preliminary research, mainly conducted in animal models, shows promise—particularly for BPC157—their effectiveness and safety in humans requires further investigation, as most studies remain in the preclinical stage.

The market for therapeutic peptides has seen significant growth, with a projected expansion of 9% annually and numerous FDA-approved peptide medications and clinical trials in progress. BPC-157, in particular, shows promise due to its favorable pharmacokinetic profile, being naturally isolated, stable, and easily metabolized. There is a need for rigorous clinical trials to establish their safety and efficacy in human subjects. Without these studies, the therapeutic applications of these peptides remain speculative, emphasizing the need for further research to elucidate their roles in injury treatment and recovery.

Conclusions

Peptide therapy is gaining attention as a promising frontier in medicine, harnessing the power of peptides—short chains of amino acids that play crucial roles in biological processes—to treat a variety of conditions. This innovative approach leverages the specificity and efficiency of peptides to enhance healing, modulate immune responses, and promote hormonal balance, offering potential treatments for autoimmune disorders, metabolic syndromes, and age-related diseases. As research advances and the understanding of peptide mechanisms deepens, peptide therapy could transform personalized medicine, providing targeted solutions with fewer side effects compared to traditional pharmaceuticals. It is our stance that peptides are the medications of the future using natural products based on cellular science to prevent and treat diseases.

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Citation of this Article

Rehmani R and Demian H. Peptide Therapy: The Future of Medicine. Mega J Case Rep. 2025;8(5):2001-2007.

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