

The Future of Prosthetics and Organ Transplantation: A Therapeutic Approach Across Various Medical Disciplines

Authors:

Khadijeh Harati

ERIS Research Institute

Maryam Tahernejad

Atilim University

Shahad Mohammed Saddam Saddam

Atilim University

Mohsen Farshi

Isfahan University of Medical Sciences

Mahbubeh Saeedfar

Kashan University of Medical Sciences & Health Services

Mobina Gheibi

Mazandaran University of Medical Sciences

Mohammad Khajehei

Ahvaz Jundishapur University of Medical Sciences

Kamyab Komaee Koma

Southeast University

Khotan Sardari

Atilim University

Seyyede Fatemeh Asghari

China Medical University

KHADIJEH HARATI

Amirsalar Motamedi
Shiraz University of Medical Sciences

THE FUTURE OF PROSTHETICS AND ORGAN TRANSPLAN...

KHADIJEH HARATI

Book Details:

Publisher: Kindle

Publication Date: May 2025

Language: English

Dimensions: 5 x 0.39 x 8 inches

© Kindle and PreferPub 2025

ISBN-13: 979-8285227373

This peer-reviewed book is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specially the rights of translation, reprinting, result of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

THE FUTURE OF PROSTHETICS AND ORGAN TRANSPLAN...

Contents

Chapter

- 1- Advancement of Prosthetics and Organ Transplantation for Renal Diseases
- 2- Advancement of Prosthetics and Organ Transplantation for Neurological Diseases
- 3- Advancement of Prosthetics and Organ Transplantation for Gastrointestinal Diseases
- 4- Advancement of Prosthetics and Organ Transplantation for Cardiac Diseases
- 5- Advancement of Prosthetics and Organ Transplantation for Pulmonary and Respiratory Diseases
- 6- Advancement of Prosthetics and Organ Transplantation for Ophthalmological Diseases
- 7- Advancement of Prosthetics and Organ Transplantation for Oral Diseases
- 8- Advancement of Prosthetics and Organ Transplantation for ENT Diseases
- 9- Advancement of Prosthetics and Organ Transplantation for Orthopedic Diseases
- 10- Advancement of Prosthetics and Organ Transplantation for Other Diseases

1- ADVANCEMENT OF PROSTHETICS AND ORGAN TRANSPLANTATION FOR RENAL DISEASES

Background

Renal diseases, particularly chronic kidney disease (CKD) and end-stage renal disease (ESRD), are among the most serious public health challenges worldwide. Affecting hundreds of millions of individuals, these conditions are associated with high morbidity, mortality, and economic burden. While dialysis has historically served as a primary life-sustaining treatment, its limitations in quality of life, cost, and long-term outcomes have pushed the field toward more definitive solutions such as organ transplantation. Alongside, prosthetic and bioengineering technologies have made significant strides in supplementing and even substituting natural renal function. The past few decades have witnessed transformative advancements in both prosthetics and organ transplantation aimed at improving treatment efficacy and restoring renal function in patients with severe kidney disease.

Evolution of Kidney Transplantation

Kidney transplantation remains the gold standard for treating end-stage renal disease. The first successful human kidney transplant was performed in 1954 between identical twins, marking a turning point in the field of organ replacement. Since then, transplantation techniques, immunosuppressive regimens, and donor-recipient matching protocols have evolved considerably. Improvements in surgical methods, including laparoscopic and robotic techniques, have minimized complications and accelerated recovery times. Advances in histocompatibility testing and the use of novel immunosuppressive agents such as tacrolimus, mycophenolate mofetil, and monoclonal antibodies have significantly increased graft survival rates and reduced episodes of acute rejection.

Furthermore, expanded criteria donor (ECD) kidneys and donation after circulatory death (DCD) have broadened the donor pool. Paired kidney exchange programs, desensitization protocols, and ABO-incompatible transplantations have made it possible for more patients to receive suitable organs. These innovations have collectively led to substantial improvements in post-transplant outcomes, patient survival, and long-term graft function.

Challenges and Limitations in Renal Transplantation

Despite remarkable progress, kidney transplantation is still limited by several factors. The global demand for donor kidneys far exceeds the supply, resulting in prolonged wait times and high mortality rates among patients on transplant lists. Organ rejection remains a significant concern, especially in cases involving sensitized recipients. Chronic allograft nephropathy, infections due to immunosuppression, and complications such as cardiovascular disease and malignancies continue to affect long-term outcomes. Additionally, disparities in access to transplantation exist based on geography, socioeconomic status, and ethnicity.

To address these challenges, ongoing research is focusing on strategies such as xenotransplantation, regenerative medicine, and tolerance-inducing therapies that aim to reduce dependence on lifelong immunosuppression. Understanding the immunological mechanisms of graft rejection and tolerance remains a central goal in transplant immunology.

Artificial Kidneys and Renal Prosthetics

One of the most groundbreaking areas of research in renal medicine is the development of artificial kidneys and renal prosthetic devices. The artificial kidney, unlike traditional dialysis, seeks to mimic the natural filtration and endocrine functions

of the human kidney. This concept combines advances in bioengineering, nanotechnology, and cell biology to create implantable or wearable devices that could one day serve as alternatives to transplantation.

The most notable example is the implantable bioartificial kidney being developed by the Kidney Project, a collaboration between the University of California, San Francisco and Vanderbilt University. This device integrates a silicon nanofilter to perform blood filtration with a bioreactor containing renal tubular epithelial cells to replicate reabsorptive and secretory functions. Powered by blood pressure and designed to be immunologically inert, this device holds the promise of continuous, dialysis-free renal support without the need for immunosuppression.

Wearable dialysis devices are also being explored as interim solutions. These include wearable hemodialysis machines that offer increased mobility, reduce hospital visits, and improve patients' quality of life. Although still in experimental stages, such innovations represent a step toward patient-centered, flexible renal care.

Tissue Engineering and Bioartificial Organs

The field of tissue engineering is providing novel solutions to address the shortage of transplantable organs. Researchers are exploring

the use of decellularized scaffolds, 3D bioprinting, and stem cell technology to create bioartificial kidneys capable of reproducing the complex architecture and function of native renal tissue. Decellularization involves removing cellular components from donor organs, leaving behind an extracellular matrix scaffold that can be repopulated with the recipient's own cells to minimize immune rejection.

3D bioprinting allows for the precise layering of renal cells and biomaterials to create microstructures resembling nephrons, glomeruli, and tubules. Although creating a fully functional bioprinted kidney is still years away, proof-of-concept models have shown success in producing tissue constructs that demonstrate partial filtration, secretion, and reabsorption capabilities.

Stem cell technology, including the use of induced pluripotent stem cells (iPSCs), offers the potential to generate patient-specific renal cells for therapeutic applications. iPSCs can be directed to differentiate into various renal cell types, which could be used in regenerative therapies, disease modeling, or for seeding tissue-engineered constructs. The integration of tissue engineering and regenerative medicine may ultimately lead to the creation of custom-designed renal grafts that overcome current limitations in donor availability and immune compatibility.

Role of Artificial Intelligence in Renal Prosthetics and Transplantation

Artificial intelligence (AI) is playing a growing role in enhancing the precision and personalization of renal prosthetics and transplantation. Machine learning algorithms are being applied to predict graft outcomes, optimize immunosuppressive regimens, and identify early signs of rejection. AI-driven platforms can integrate and analyze large datasets, including genomic, proteomic, and imaging data, to assist clinicians in making informed decisions.

In prosthetic development, AI contributes to the design and functional optimization of wearable and implantable devices. Predictive modeling can help simulate patient-specific outcomes and guide the customization of device settings. In addition, AI enhances remote monitoring of patients through smart sensors embedded in prosthetic devices, allowing for real-time feedback, early detection of complications, and personalized therapy adjustments.

These technologies collectively support the shift toward precision medicine in nephrology, where treatment plans are tailored to the individual's unique biological profile, thereby improving efficacy and minimizing adverse effects.

Ethical and Regulatory Considerations

The advancement of prosthetics and organ transplantation in renal diseases raises important ethical and regulatory questions. The allocation of scarce donor organs, informed consent, access to experimental therapies, and the cost of emerging technologies must be carefully addressed. Equity in access to transplantation and artificial devices remains a major concern, especially in low and middle income countries where healthcare infrastructure and resources are limited.

There is also an ethical imperative to ensure that developments in regenerative medicine and artificial organ technology are rigorously tested for safety and efficacy before widespread adoption. Regulatory frameworks must evolve to accommodate novel therapies, balancing innovation with patient protection. Collaboration among scientists, clinicians, ethicists, policymakers, and patient advocacy groups is essential to navigate these challenges and ensure responsible progress.

Pediatric Considerations in Renal Transplantation and Prosthetics

Renal disease in children poses unique challenges that differ from adult cases. Children with ESRD

often face growth retardation, developmental delays, and increased psychosocial stress. Kidney transplantation offers the best long-term outcome for pediatric patients, but graft survival can be lower due to immune system immaturity and increased likelihood of repeated transplants throughout life.

Prosthetic innovations and wearable devices tailored for pediatric use are essential to ensure adherence, minimize discomfort, and support active lifestyles. Pediatric applications of bioartificial kidneys and tissue-engineered grafts are being investigated to address the anatomical and physiological differences in younger patients. Furthermore, ethical considerations surrounding consent and assent, long-term outcomes, and quality of life are particularly critical in this vulnerable population.

Global Perspectives and Future Outlook

The global burden of renal disease continues to rise, driven by increasing rates of diabetes, hypertension, and aging populations. In response, international efforts are being made to expand access to transplantation and renal prosthetic technologies. Countries are developing national transplant registries, public awareness campaigns, and opt-out organ donation policies to improve organ availability. Technological innovations are

being tailored to meet local healthcare needs and resource availability.

Looking forward, the integration of biotechnology, material science, computational modeling, and personalized medicine is expected to redefine the landscape of renal disease management. Innovations such as smart dialysis membranes, nanotechnology-enabled drug delivery, gene editing for immunomodulation, and the development of complete nephron units through organoid culture are on the horizon.

In parallel, the advancement of health systems, training of specialists, and development of supportive care infrastructure are essential to translating these scientific gains into equitable and sustainable solutions. Collaborative, interdisciplinary research and global partnerships will be key in transforming the promise of these technologies into real-world impact.

Conclusion

The advancement of prosthetics and organ transplantation for renal diseases reflects a remarkable intersection of science, technology, and medicine. From the evolution of kidney transplantation to the emergence of bioartificial kidneys and neuroprosthetics, these innovations are revolutionizing how renal failure is managed. While challenges remain, particularly in terms of accessibility, ethical concerns, and biological

KHADIJEH HARATI

complexity, the momentum of innovation continues to grow. By bridging engineering, clinical practice, and patient-centered care, the future holds the promise of more effective, personalized, and humane solutions for those affected by renal diseases. With sustained research, collaborative effort, and responsible governance, the goal of restoring kidney function and improving lives is steadily becoming a reality.

THE FUTURE OF PROSTHETICS AND ORGAN TRANSPLAN...

2- ADVANCEMENT OF PROSTHETICS AND ORGAN TRANSPLANTATION FOR NEUROLOGICAL DISEASES

Background

Prosthetics and organ transplantation have made extraordinary strides over the last few decades, particularly in the field of neurological diseases. The convergence of innovative technologies, advanced medical research, and human resilience has significantly transformed the lives of individuals suffering from various neurological conditions. Neurological diseases can result in limb loss or impair motor functions. Traditionally, prosthetics were rudimentary devices designed to enable basic movement. However, with the advent of advanced technology, prosthetics have evolved to restore a greater degree of function and even the sense of touch. Modern prosthetic devices are now capable of integrating with the body's nervous system, enabling users to control them using their thoughts.

One groundbreaking innovation is the development of myoelectric prosthetic limbs, which utilize electrical signals generated by the user's muscles to control the prosthesis. These devices can execute fine motor tasks, such as

grasping small objects, significantly enhancing the user's quality of life. Furthermore, recent progress in neuroprosthetics has introduced brain-machine interfaces (BMIs), allowing for direct communication between the brain and the prosthetic limb. These interfaces decode neural signals and convert them into movement, enabling more seamless and intuitive control. Organ transplantation has also experienced remarkable progress, particularly in patients with neurological diseases that affect vital organs such as the liver, kidneys, or pancreas. Advances in immunosuppressive therapy have greatly improved transplant outcomes by reducing the risk of organ rejection. Moreover, innovative techniques such as ex vivo organ perfusion and tissue engineering have expanded the pool of viable organs available for transplantation.

For patients with neurological conditions like Parkinson's and Huntington's disease, organ transplantation can be transformative. For example, pancreas transplantation in individuals with Type 1 diabetes—often accompanied by neurological complications—can restore insulin production and significantly improve glycemic control. This, in turn, can alleviate certain neurological symptoms and enhance the patient's overall health. The future of prosthetics and organ transplantation for neurological diseases holds vast promise. Researchers are actively exploring the potential of stem cell therapy and regenerative

medicine to create bioengineered organs and tissues, which could potentially eliminate the reliance on donor organs and reduce the risk of transplant rejection.

In the field of prosthetics, scientists are focused on developing “smart” prosthetic devices that can deliver sensory feedback to the user. These advanced devices aim to replicate sensations such as pressure, temperature, and texture, allowing the prosthetic to feel more like a natural extension of the body. Additionally, innovations in materials science are producing lighter, more durable, and more lifelike prosthetics. The advancements in prosthetics and organ transplantation for neurological diseases have brought renewed hope and improved quality of life for many patients. As technology continues to progress, the potential for future breakthroughs remains immense. The integration of cutting-edge research, innovative technologies, and the dedication of medical professionals will continue to push the boundaries of what is possible, offering new opportunities and better outcomes for individuals affected by neurological diseases.

Transplantation is a highly effective therapeutic intervention for end stage organ failure and is often complemented by prosthetic solutions when appropriate. Each year, over 110,000 solid organ transplantations are performed as life saving procedures. It continues to be one of the

most dynamic and innovative fields in modern medicine. The concept of transferring living components from one organism to another has fascinated humans for centuries. This enduring curiosity has also contributed to the evolution of prosthetics, which are technological innovations that enable individuals to restore or replace lost physiological functions due to injury, illness, or congenital conditions. These technologies have advanced significantly, progressing from rudimentary tools to sophisticated devices that integrate with the human body and enhance mobility, sensory perception, and cognitive abilities.

Neural oscillations are a fundamental component of the nervous system and play a critical role in supporting sensory, motor, and cognitive functions in both the brain and spinal cord. These oscillations are frequently disrupted in neurodegenerative and neuropsychiatric disorders, including traumatic brain injury, stroke, and spinal cord injury. Neuroprosthetics are devices designed to augment or restore motor, sensory, or cognitive communication functions by stimulating and utilizing preserved brain and spinal pathways. They aim to compensate for existing neural dysfunction and assist patients in regaining lost abilities. Among the most effective neuroprosthetic devices developed to date are cochlear implants for individuals with

hearing loss and limb prostheses for amputees. Newer and increasingly transformative devices include neural interfaces, bionic limbs, and brain computer interfaces, which hold promising potential in the treatment and management of a wide range of neurological disorders. In recent years, the convergence of regenerative medicine, bioengineering, and neurotechnology, together with advancements in systems neuroscience, a field that explores brain function at the level of neural networks, has laid the foundation for a deeper understanding of how the brain and nervous system operate as interconnected circuits. This scientific foundation, along with emerging technologies such as artificial intelligence and three dimensional printing, is expected to expand the possibilities for neural restoration in patients suffering from nervous system disorders.

Despite impressive progress in prosthetics and organ transplantation, significant challenges and unresolved issues remain. The nervous system is composed of an immense number of neuronal cells, and this complexity creates major obstacles in fully understanding its function and in designing neuroprosthetic devices that can effectively replicate or replace it. Although devices such as deep brain stimulation systems and brain computer interfaces have shown notable success, their occasional limitations in effectiveness and precision may result in unintended side effects.

These concerns require careful evaluation of the risks and benefits associated with their clinical use. Moreover, the high cost of implantation, ongoing monitoring, and the limited availability of neuroprosthetic technologies may prevent access for many individuals in both research and clinical settings.

This research is motivated by the urgent need to address these issues and to advance the fields of prosthetics and organ transplantation in the context of neurological disorders. By overcoming the current limitations in neuroprosthetic devices and transplantation techniques, it is possible to significantly improve functional outcomes, enhance the quality of life, and reduce the societal and economic burden of these debilitating conditions. Reaching this goal requires a multidisciplinary approach that integrates neuroscience, bioengineering, regenerative medicine, and clinical practice.

Historical Perspectives and Early Developments

The history of prosthetics in neurological rehabilitation dates back centuries, with rudimentary limb replacements used as early as ancient civilizations. However, it was not until the twentieth century that prosthetics began to be scientifically engineered to mimic and restore biological function. In the realm of

neurology, early prosthetic devices were primarily mechanical, aimed at supporting mobility or compensating for limb loss. With the introduction of electronic components and biomedical engineering, prosthetics rapidly evolved into more sophisticated systems capable of interacting with the nervous system.

Organ transplantation, particularly of the peripheral nerves and vascularized composite allografts, also emerged as a vital therapeutic strategy. Although central nervous system (CNS) transplantation remains a significant challenge due to the complexity and immunological sensitivity of brain tissue, surgical approaches to peripheral nerve and muscle transplantation laid the groundwork for future interventions in neurological repair.

Neuroprosthetics and Brain-Machine Interfaces

One of the most transformative fields in neurological rehabilitation is neuroprosthetics. These are devices designed to replace or enhance functions lost due to neurological damage by directly interfacing with the nervous system. Among the most notable examples are cochlear implants, which have restored hearing to individuals with sensorineural deafness. These devices work by converting sound into electrical signals that directly stimulate the auditory nerve,

bypassing damaged sensory structures.

Building upon this model, brain-machine interfaces (BMIs), also referred to as brain-computer interfaces (BCIs), have emerged as pioneering technologies that enable direct communication between the brain and external devices. These systems translate neural signals into commands that can control prosthetic limbs, computer cursors, or even exoskeletons. For patients with spinal cord injuries or locked-in syndromes, BMIs provide a means of regaining communication and interaction with their environment, a breakthrough that was once considered science fiction.

Invasive BMIs, which involve electrodes implanted directly into cortical tissue, offer higher signal fidelity and greater control but carry risks of infection and tissue damage. Non-invasive approaches, such as electroencephalography (EEG)-based systems, are safer but limited in precision. Hybrid systems combining multiple input modalities are being developed to optimize performance and usability. With advances in signal processing, machine learning, and wireless technology, BMIs are steadily moving from experimental labs to clinical application.

Advancements in Motor Prosthetics

Motor prosthetics have made exceptional progress

in replicating and augmenting lost limb function. These devices are now capable of responding to neural or myoelectric signals to perform a variety of complex tasks, such as grasping, writing, or manipulating objects. Myoelectric prostheses detect electrical activity from residual muscles in amputated limbs to drive motorized components. More advanced systems, often integrated with BMIs, allow for intuitive control by decoding intentions directly from cortical activity.

One of the significant advancements in this domain is the development of sensory feedback in motor prosthetics. Traditional prosthetic limbs functioned unidirectionally, translating user intent into movement without providing sensory information. Newer prosthetic systems incorporate sensors that detect pressure, temperature, and texture and relay this information back to the nervous system through electrical stimulation or direct neural interfaces. This bidirectional communication allows users to "feel" through the prosthetic, improving control, safety, and the overall sense of embodiment.

Visual and Auditory Neuroprostheses

In addition to motor restoration, neuroprosthetic devices have been successfully developed to address sensory deficits. Cochlear implants remain the most widely used auditory

neuroprosthetic, with over 600,000 users worldwide. These devices have undergone significant improvements in sound fidelity, speech recognition, and compatibility with wireless technology.

Visual prosthetics, or retinal implants, represent another frontier in neuroprosthetics. Designed to restore partial vision to individuals with retinal degenerative diseases such as retinitis pigmentosa and age-related macular degeneration, these implants work by stimulating remaining viable retinal cells or directly interfacing with the optic nerve. Devices like the Argus II retinal implant system have demonstrated the ability to enable users to perceive light, shapes, and motion, significantly enhancing their autonomy.

Future developments in visual prostheses are focusing on cortical visual prosthetics that bypass the damaged eye altogether and stimulate the visual cortex directly. These devices offer potential solutions for individuals with damage to the optic nerve or severe ocular pathology that prevents the use of retinal implants.

Deep Brain Stimulation and Neuromodulation

Deep brain stimulation (DBS) is a well-established neuroprosthetic technique used in the management of movement disorders, particularly Parkinson's disease. This technique involves the

implantation of electrodes into specific brain regions, such as the subthalamic nucleus or globus pallidus, to modulate neural activity through continuous electrical impulses. DBS has been shown to alleviate tremors, rigidity, and bradykinesia, significantly improving quality of life for patients who do not respond adequately to pharmacologic therapy.

Beyond movement disorders, DBS is being investigated for a range of neurological and psychiatric conditions, including epilepsy, depression, obsessive-compulsive disorder, and chronic pain. The precise mechanisms of action remain under investigation, but the success of DBS underscores the therapeutic potential of electrical modulation in restoring neural function.

Other forms of neuromodulation, such as transcranial magnetic stimulation (TMS) and vagus nerve stimulation (VNS), offer non-invasive or minimally invasive alternatives for modulating brain activity. These techniques are gaining attention for their potential in treating conditions like stroke, traumatic brain injury, and cognitive disorders.

Organ Transplantation in Neurological Disorders

Organ transplantation plays a vital role in managing neurological conditions that result from or lead to multi-organ failure. For instance,

liver transplantation is a life-saving treatment for hepatic encephalopathy, a condition in which liver failure leads to neurotoxicity and altered mental status. Kidney transplantation may be required in patients with neurological complications arising from chronic kidney disease, including uremic encephalopathy and neuropathy.

More direct applications of transplantation in neurology involve peripheral nerve, muscle, and vascularized composite allotransplants. Hand and face transplants, while still rare, have been performed successfully in patients with traumatic limb or facial loss. These procedures restore not only form but function, including sensation and motor control, thereby transforming patients' lives.

Neural stem cell transplantation is another promising area of research. These stem cells have the potential to differentiate into various neural cell types and are being investigated for the treatment of spinal cord injury, stroke, and neurodegenerative diseases. Early clinical trials have shown encouraging results in terms of safety, integration, and preliminary functional recovery.

Tissue Engineering and Regenerative Medicine

Tissue engineering and regenerative medicine offer potential alternatives to organ transplantation by focusing on the repair and

regeneration of damaged neural tissue. Stem cells, including embryonic stem cells, adult stem cells, and induced pluripotent stem cells, are central to these approaches. These cells can be programmed to generate neurons, glial cells, and supporting tissues, offering possibilities for replacing cells lost to disease or injury.

Three dimensional bioprinting is being explored to construct neural tissues with precise architecture and cellular composition. While constructing entire functional brain regions remains a distant goal, engineered neural tissues can be used for transplantation, disease modeling, and drug screening. Bioengineered scaffolds, growth factors, and extracellular matrix components are used to guide stem cell differentiation and integration into host tissues.

This field is also contributing to the development of neural organoids—miniature, simplified versions of brain structures grown in vitro. These organoids are valuable tools for studying development, disease mechanisms, and drug responses, and may eventually play a role in personalized therapy.

Integration of Artificial Intelligence and Neurotechnology

Artificial intelligence is increasingly integrated into neuroprosthetic systems to improve

functionality, adaptability, and user experience. AI algorithms can interpret complex neural signals, optimize device performance, and provide real-time adjustments based on feedback. In BMIs, machine learning is used to decode motor intentions, speech patterns, or emotional states, allowing for more natural and efficient interaction between the brain and external devices.

Smart neuroprosthetics equipped with AI can learn from user behavior, adapt to changing neurological conditions, and predict complications. This makes them more intuitive and reduces the cognitive burden on users. Additionally, AI facilitates remote monitoring, predictive maintenance, and outcome assessment, enabling proactive clinical interventions.

In the research domain, AI is accelerating the analysis of neuroimaging, genomics, and electrophysiological data. These insights are guiding the development of targeted therapies, refining surgical planning, and personalizing neuromodulation protocols.

Ethical and Societal Considerations

The advancement of prosthetics and organ transplantation in neurology raises profound ethical and societal questions. Issues of identity, consent, access, and enhancement versus restoration are central to the discourse. For

example, the integration of neuroprosthetics that enhance cognitive or physical performance beyond normal human capacity challenges traditional definitions of disability and therapy.

Equity in access to these advanced technologies remains a pressing concern. High costs, limited availability, and the concentration of expertise in high income countries create disparities in who can benefit from these innovations. Addressing these gaps requires policy reforms, global collaboration, and investment in health infrastructure and education.

Long-term safety, privacy, and data security are also crucial considerations, particularly as AI driven devices become more autonomous and interconnected. Regulations must evolve to ensure patient protection without stifling innovation.

Future Directions and Conclusion

The future of prosthetics and organ transplantation for neurological diseases is both promising and complex. Multidisciplinary collaboration among neuroscientists, engineers, clinicians, ethicists, and policymakers will be essential to translate technological breakthroughs into practical solutions. Emerging trends include the development of fully implantable BMIs, bioelectronic medicines, personalized stem cell therapies, and smart neural devices capable of self-

regulation.

As the boundaries between biology and technology continue to blur, the goal of restoring function to individuals with neurological diseases is becoming increasingly attainable. Continued investment in research, ethical deliberation, and patient-centered care will be essential to ensure these advances fulfill their potential to transform lives.

3- ADVANCEMENT OF PROSTHETICS AND ORGAN TRANSPLANTATION FOR GASTROINTESTINAL DISEASES

Background

Gastrointestinal (GI) diseases encompass a wide array of disorders affecting the digestive tract, including congenital anomalies, inflammatory conditions, functional disorders, neoplasms, and diseases leading to organ failure. The progression of many of these conditions, particularly those involving the liver, intestines, or pancreas, often leads to irreversible damage that significantly impairs digestion, nutrient absorption, and metabolism. As traditional treatments reach their limits in advanced cases, the fields of prosthetics and organ transplantation have emerged as powerful alternatives to restore or replace lost gastrointestinal function. In recent decades, scientific and technological advancements have revolutionized how such diseases are managed, extending survival, enhancing quality of life, and offering hope to patients once considered beyond the reach of curative care.

The Evolution and Impact of Liver Transplantation

Liver transplantation remains one of the most significant achievements in gastrointestinal medicine. Since the first successful human liver transplant in 1967, the procedure has evolved from an experimental therapy into a life-saving treatment for thousands of patients worldwide suffering from end-stage liver diseases such as cirrhosis, acute liver failure, hepatocellular carcinoma, and inherited metabolic disorders. Improvements in surgical techniques, perioperative care, and immunosuppressive regimens have led to remarkable gains in graft survival and patient outcomes.

Living donor liver transplantation has further expanded the donor pool and reduced waitlist mortality, especially in pediatric patients. Advances in imaging and intraoperative navigation have enhanced the precision of hepatic resections and graft implantations. Furthermore, the use of marginal or extended criteria donors, once considered high-risk, is now feasible due to better preservation techniques and immunological management. Despite these advancements, organ shortage remains a major obstacle, motivating ongoing exploration into alternative solutions such as bioartificial livers and xenotransplantation.

Small Intestine and Multivisceral Transplantation

Although less common than liver transplantation, small bowel transplantation has gained increasing importance in managing patients with intestinal failure who cannot be sustained on total parenteral nutrition (TPN) due to complications such as liver dysfunction, infections, or central venous catheter problems. Once burdened by high rejection and mortality rates, small intestine transplantation has seen improved outcomes with the introduction of tacrolimus-based immunosuppression, refined surgical techniques, and better patient selection.

In some patients with complex abdominal pathologies involving multiple organs—such as severe mesenteric ischemia, Crohn's disease, or extensive abdominal surgeries—multivisceral transplantation, involving the simultaneous replacement of the stomach, pancreas, intestines, and liver, may be indicated. Though technically demanding and associated with significant risks, this approach has demonstrated success in selected cases and exemplifies the potential of transplantation to comprehensively restore gastrointestinal physiology.

Pancreatic Transplantation in Gastrointestinal Disease Contexts

While traditionally considered an endocrine organ, the pancreas plays a central role

in gastrointestinal function through its exocrine secretions. Pancreas transplantation, often performed in conjunction with kidney transplantation for diabetic patients, can restore both endocrine and exocrine function. In the context of gastrointestinal diseases, pancreas transplantation may also benefit patients with severe chronic pancreatitis, malabsorption, or pancreatic exocrine insufficiency.

The refinement of surgical methods, better control of immunological responses, and enhanced management of exocrine drainage have all contributed to improved graft survival and reduced complications. Ongoing research is exploring the possibility of using islet cell transplantation, a less invasive procedure, to restore insulin secretion without necessitating whole-organ transplantation. Although this approach primarily addresses metabolic disease, its implications for digestive enzyme regulation and gastrointestinal function are increasingly recognized.

Gastrointestinal Prosthetics and Their Clinical Applications

Prosthetic innovations in gastrointestinal medicine span a range of devices designed to support or replace functions compromised by disease or surgical resection. These include esophageal stents, artificial sphincters, gastric

bands, intestinal liners, and internal support structures used in reconstructive surgeries.

Esophageal prosthetics, such as self-expanding metallic stents, are commonly employed to relieve dysphagia caused by malignancies or strictures. These stents provide palliation and allow oral intake in patients who would otherwise require feeding tubes or parenteral nutrition. Similarly, prosthetic devices for the anal sphincter offer therapeutic options for patients with severe fecal incontinence, whether due to congenital anomalies, trauma, or neurogenic disorders. These devices use hydraulic, magnetic, or mechanical systems to mimic the function of natural sphincters and can be activated voluntarily by the patient.

In bariatric and metabolic surgery, prosthetics like intragastric balloons and adjustable gastric bands have transformed the treatment of obesity-related gastrointestinal diseases. These devices modulate satiety and gastric volume, providing non-permanent, minimally invasive options for weight management and metabolic control. Additionally, bioabsorbable intestinal liners are being investigated for their ability to mimic the bypass effect of metabolic surgeries, influencing gut hormones and glycemic control without anatomical alteration.

Intestinal Engineering and

Tissue Regeneration

The development of bioengineered intestines represents one of the most promising frontiers in gastrointestinal prosthetics. Intestinal tissue engineering aims to construct functional gut segments capable of performing absorption, secretion, and peristalsis. This involves the use of scaffolds—either synthetic or derived from decellularized tissue—seeded with intestinal epithelial and smooth muscle cells, often derived from patient-specific stem cells.

Experimental models have demonstrated the successful generation of intestinal grafts that exhibit structural and functional similarity to native bowel. These constructs can be anastomosed to the host bowel and perfused with blood vessels, offering hope for patients with short bowel syndrome or congenital malformations who lack sufficient absorptive surface. Although clinical application remains limited, ongoing studies are refining scaffold materials, cell sources, and vascularization techniques to bring this technology closer to reality.

In parallel, the use of growth factors, extracellular matrix components, and regenerative agents is being explored to enhance the healing of GI mucosa and reduce postoperative complications. These approaches aim to accelerate mucosal regeneration, prevent strictures and leaks, and support the integrity of anastomoses.

Enteric Nervous System and Neuroprosthetics

The gastrointestinal tract is governed by the enteric nervous system, often referred to as the “second brain” due to its complex and autonomous control of motility, secretion, and reflexes. In disorders such as gastroparesis, Hirschsprung’s disease, and chronic intestinal pseudo-obstruction, the dysfunction of this nervous system leads to severe morbidity.

Neuroprosthetic approaches are being investigated to restore control in these cases. Electrical stimulation of the stomach (gastric pacing) has shown benefits in selected patients with refractory nausea and vomiting. Similarly, sacral nerve stimulation, already used in urinary incontinence, is being adapted for fecal incontinence and bowel dysfunction. These methods aim to modulate neural signals and improve coordination between the central and enteric nervous systems.

Future directions include the development of bioelectronic medicines—implantable devices that interface with enteric nerves to modulate gastrointestinal function in real-time. These approaches offer the potential for precise, adjustable, and non-pharmacologic management of motility disorders.

Artificial Organs and Assist Devices in Gastrointestinal Medicine

The concept of artificial organs in gastrointestinal care is expanding beyond traditional prosthetics. Bioartificial livers, for example, incorporate living hepatocytes within a device that performs key detoxification and metabolic functions. These systems serve as temporary support for patients with acute liver failure, bridging them to transplantation or recovery. Although challenges remain in maintaining cell viability and avoiding immune reactions, pilot studies have demonstrated clinical benefit in reducing encephalopathy and improving survival.

In the realm of digestive enzyme supplementation, artificial pancreas systems are being designed to synchronize insulin and glucagon delivery with real-time glucose monitoring. While primarily developed for diabetes management, these closed-loop systems have implications for broader digestive and metabolic regulation, particularly in patients with exocrine pancreatic insufficiency.

Prototypes of artificial intestines, integrating sensor-based feedback, microfluidics, and biocompatible materials, are being tested for nutrient absorption, hormonal signaling, and microbiome interaction. These devices, though

experimental, reflect the convergence of engineering, biology, and digital health in creating next-generation solutions for digestive diseases.

Role of Artificial Intelligence and Robotics in GI Prosthetics and Transplantation

Artificial intelligence is playing an increasingly important role in gastrointestinal surgery, transplantation, and prosthetic design. AI algorithms are being used to predict transplant outcomes, match donors with recipients, and optimize immunosuppressive protocols. Machine learning models can integrate clinical, genomic, and imaging data to guide patient selection, anticipate rejection episodes, and personalize treatment strategies.

In prosthetics, AI facilitates the design of adaptive, user-responsive devices. Smart gastrointestinal implants can monitor physiological parameters and adjust function accordingly. For example, a smart gastric band could adjust pressure in response to satiety hormones or neural feedback, enhancing safety and efficacy.

Robotic surgery has revolutionized the precision of GI procedures, including transplantations and prosthetic implantations. Robot-assisted systems provide greater dexterity, stability, and visualization, reducing complications and enhancing recovery. Their use is expanding

in hepatic resections, pancreatic surgeries, and complex abdominal reconstructions.

Ethical Considerations and Access Challenges

The rapid advancement of transplantation and prosthetic technologies in gastrointestinal medicine raises important ethical questions. Access to transplantation is often limited by organ availability, socioeconomic disparities, and geographic inequalities. The high cost of prosthetic devices and regenerative therapies may further exacerbate inequities in care.

Ethical issues also arise regarding consent, especially in pediatric patients or those undergoing experimental procedures. The use of animal-derived tissues or genetically modified organs for xenotransplantation introduces additional moral concerns. Balancing innovation with patient safety, autonomy, and justice requires robust ethical frameworks and inclusive policymaking.

Global efforts are needed to expand organ donation, reduce costs, and ensure equitable access to advanced gastrointestinal therapies. Investment in training, infrastructure, and regulatory oversight will be essential to support responsible dissemination of these technologies.

Conclusion

The advancement of prosthetics and organ transplantation for gastrointestinal diseases represents a transformative shift in the landscape of digestive healthcare. From liver and intestinal transplants to bioengineered tissues, smart prosthetics, and neuroelectronic interfaces, the range of tools available to restore GI function is rapidly expanding. These innovations not only prolong life but also dramatically enhance its quality for patients who once had few options.

While significant challenges remain—including organ shortages, immune compatibility, technical limitations, and cost barriers—the momentum of scientific discovery and interdisciplinary collaboration is steadily overcoming them. The integration of bioengineering, regenerative medicine, robotics, and artificial intelligence is creating a future where gastrointestinal diseases can be managed with unprecedented precision, safety, and personalization.

As these technologies evolve, continued focus on ethical governance, global equity, and patient-centered design will be crucial. By aligning technological innovation with compassionate care and inclusive access, the full promise of prosthetics and transplantation in gastrointestinal medicine can be realized, transforming the lives of patients around the

world.

4- ADVANCEMENT OF PROSTHETICS AND ORGAN TRANSPLANTATION FOR CARDIAC DISEASES

Background

Cardiovascular diseases claim millions of lives each year, with heart failure alone affecting over 56.2 million individuals. However, this number is likely much higher due to underreporting, especially in resource-limited settings. Despite substantial advancements in medical treatment, many patients with end-stage heart disease continue to face poor prognoses, primarily because the demand for donor hearts far surpasses the available supply. Nevertheless, the field of cardiac care is undergoing a transformative revolution, driven by groundbreaking advancements in prosthetics and organ transplantation. Innovations such as sophisticated artificial hearts, ventricular assist devices, bioengineered tissues, and xenotransplantation are redefining the boundaries of what is possible in the treatment of heart disease.

Heart transplantation remains widely regarded as the most effective treatment for end-stage heart failure. However, the critical shortage of

donor hearts often results in patients dying while awaiting transplantation. In response to this challenge, mechanical circulatory support devices, including left ventricular assist devices (LVADs) and total artificial hearts (TAHs), have been developed to support failing hearts. In the United States, TAHs are utilized for patients experiencing biventricular failure or for those with structural conditions that make LVADs unsuitable. The SynCardia TAH, developed by SynCardia Systems in Tucson, Arizona, is the most commonly implanted TAH and is primarily used as a bridge to transplant (BTT) rather than a permanent solution.

Studies have shown that the survival rates of patients who undergo transplantation following TAH implantation are comparable to those of patients who receive either a de novo transplant or an LVAD as a bridge to transplant—provided they survive the early postoperative period. Nonetheless, the large size of current TAH devices and the high incidence of device-related complications limit their broader application. While TAHs serve as a vital option for patients ineligible for LVADs or human heart transplants, their use is significantly hindered by complications such as infections and mechanical malfunctions, which negatively affect long-term survival outcomes.

Cardiac tissue engineering is also advancing

rapidly, contributing to drug discovery and disease modeling through the creation of functional cardiovascular components such as blood vessels and heart valves using techniques like 3D bioprinting. However, the development of a fully functional bioengineered heart remains an ambitious goal, likely requiring decades of further research and technological refinement.

Xenotransplantation—the transplantation of animal hearts into human recipients—has emerged as one of the most promising near-term alternatives to traditional heart transplantation. Earlier attempts involved non-human primate hearts, such as those from chimpanzees and baboons, but survival times were typically very short. One notable exception was Baby Fae, who survived for 20 days after receiving a baboon heart. Today, pigs have become the preferred donor species due to several advantages: their heart size and function closely resemble those of humans; they can be genetically modified to reduce the risk of rejection; they reproduce rapidly; they have relatively long lifespans (15–20 years); they present a low risk of disease transmission when raised in pathogen-free environments; and their use is generally considered ethically acceptable for life-saving purposes.

Over the past decade, remarkable progress has been achieved in pig-to-primate cardiac

xenotransplantation, fueled by breakthroughs in genetic engineering, organ preservation, preclinical modeling, immunosuppressive therapies, and methods to control post-transplant heart growth. These innovations have enabled genetically modified pig hearts to function in baboons for as long as nine months.

In January 2022, a landmark clinical case demonstrated the compassionate use of a genetically modified pig heart in a patient suffering from terminal heart failure. Although the patient ultimately died two months later, the pig heart supported life for more than 45 days, providing compelling evidence of the feasibility of clinical xenotransplantation. The patient's death may have been influenced by factors such as the presence of anti-pig antibodies, graft injury, and the reactivation of porcine cytomegalovirus. Nonetheless, this case marked a historic milestone in the advancement of cross-species heart transplantation.

Heart Transplantation and Its Evolution

Heart transplantation stands as the definitive treatment for patients with end-stage heart failure who are unresponsive to conventional medical therapy. Since the first human heart transplant performed by Dr. Christiaan Barnard in 1967, the field has made remarkable progress. Advances

in surgical techniques, donor-recipient matching, perioperative care, and immunosuppression have led to significantly improved outcomes. Today, one-year survival rates exceed 85 percent in many transplant centers, and long-term survival continues to improve.

Modern immunosuppressive regimens, including calcineurin inhibitors, corticosteroids, and antiproliferative agents, have reduced the risk of acute rejection and chronic graft dysfunction. Furthermore, improvements in organ preservation methods—such as ex vivo perfusion systems that maintain organ viability during transport—have extended the geographic reach of organ sharing, allowing for better matching and utilization of donor hearts.

Despite these advances, challenges persist. Donor organ availability remains limited, resulting in long waiting times and high mortality among patients on the transplant list. The risk of graft rejection, opportunistic infections due to immunosuppression, and the development of transplant vasculopathy continue to impact long-term outcomes. These challenges have spurred interest in alternative solutions, including mechanical circulatory support devices and regenerative therapies.

Ventricular Assist Devices and Mechanical

Circulatory Support

Ventricular assist devices have revolutionized the management of advanced heart failure, particularly in patients awaiting transplantation or those who are not candidates for transplant. These mechanical pumps are designed to support the failing heart by taking over the workload of the left, right, or both ventricles. The most commonly used devices are left ventricular assist devices (LVADs), which help circulate blood from the left ventricle to the aorta.

Initially developed as a bridge to transplant, LVADs are now increasingly used as destination therapy for patients who are not eligible for heart transplantation. Contemporary LVADs are smaller, more durable, and associated with fewer complications than earlier models. Continuous-flow LVADs have largely replaced pulsatile devices, offering better hemodynamic support and lower rates of mechanical failure.

Right ventricular assist devices (RVADs) and biventricular assist devices (BiVADs) are used in cases of right heart failure or biventricular dysfunction, though their use is more limited due to technical complexity and higher complication rates. These devices are often used in specialized centers with experience in advanced heart failure management.

The success of VADs has expanded the options for patients with severe cardiac dysfunction,

allowing many to live active, productive lives. However, complications such as bleeding, thromboembolism, device infection, and pump thrombosis remain concerns. Ongoing research aims to improve biocompatibility, minimize adverse events, and develop fully implantable, wireless energy systems.

Total Artificial Hearts and Cardiac Prostheses

For patients with irreversible biventricular failure and no immediate access to a donor heart, the total artificial heart (TAH) provides an alternative means of circulatory support. Unlike VADs, which assist the native heart, TAHs replace the ventricles entirely and maintain systemic and pulmonary circulation independently. The SynCardia TAH is the most widely used device and is primarily employed as a bridge to transplant.

While TAHs can sustain life in critically ill patients, their use is currently limited by factors such as device size, external power requirements, and the risk of complications including infection and hemolysis. Innovations in miniaturization, wireless power transfer, and biocompatible materials are being pursued to expand the applicability and safety of TAHs.

Cardiac prostheses also include a range of devices designed to replace or support specific components of the heart. Prosthetic heart valves

are among the most commonly implanted devices in cardiovascular surgery. Mechanical valves, made of durable materials such as titanium and carbon, offer long-term durability but require lifelong anticoagulation to prevent thrombosis. Bioprosthetic valves, derived from animal tissue, offer the advantage of not requiring anticoagulation but are prone to degeneration over time, especially in younger patients.

Recent advancements include transcatheter aortic valve replacement (TAVR), a minimally invasive procedure that allows for valve implantation without open-heart surgery. Initially used in high-risk surgical candidates, TAVR is now being adopted for lower-risk patients as well. Similar catheter-based approaches are being developed for mitral and tricuspid valve replacement and repair.

Bioengineering and Regenerative Approaches

The integration of bioengineering and regenerative medicine is ushering in a new era in cardiac care. Researchers are exploring the use of tissue-engineered constructs to repair or replace damaged cardiac tissues. These include bioengineered heart valves, vascular grafts, and myocardial patches created using scaffolds seeded with autologous or stem-cell-derived cells.

One of the most ambitious goals in cardiac regenerative medicine is the development of

a bioartificial heart. This would involve decellularizing a donor heart to create a scaffold and then repopulating it with the recipient's cells to avoid immune rejection. While this concept remains largely experimental, progress has been made in creating functional myocardial tissue capable of contracting and conducting electrical impulses.

Stem cell therapies are also being investigated for their potential to regenerate damaged myocardium following infarction or cardiomyopathy. Although early clinical trials have shown modest benefits, challenges remain in terms of cell delivery, survival, differentiation, and integration with host tissue. Gene therapy and exosome-based treatments are also being explored to enhance cardiac repair and modulate inflammation.

Neuroprosthetics and Autonomic Regulation

The heart is regulated by a complex interplay between the autonomic nervous system and intrinsic cardiac neurons. Dysregulation of this control contributes to arrhythmias, heart failure progression, and sudden cardiac death. Neuroprosthetic devices targeting the autonomic nervous system are being developed to modulate cardiac function more precisely.

One such device is vagus nerve stimulation

(VNS), which aims to enhance parasympathetic tone and reduce sympathetic overactivity in heart failure. Preclinical studies and early-phase clinical trials have demonstrated improvements in heart rate variability, cardiac output, and quality of life. Other devices target spinal cord or carotid baroreceptors to achieve similar autonomic modulation.

Cardiac resynchronization therapy (CRT), though not a neuroprosthetic in the traditional sense, exemplifies how electrical stimulation can be used to restore coordinated myocardial contraction in patients with conduction abnormalities. CRT devices have become standard therapy in selected heart failure patients with reduced ejection fraction and bundle branch block.

Wearable and Implantable Monitoring Technologies

The proliferation of wearable and implantable monitoring technologies has significantly impacted the management of cardiac diseases. Devices such as implantable loop recorders, ambulatory ECG monitors, and smartwatches with ECG capability provide continuous or intermittent rhythm surveillance, facilitating early detection of arrhythmias, ischemia, and decompensation.

Remote monitoring of VADs, pacemakers, and defibrillators allows clinicians to track

device function, adjust parameters, and detect complications without the need for frequent clinic visits. This has become particularly valuable in the context of telemedicine and during times when access to in-person care is limited.

Artificial intelligence is being integrated into these platforms to analyze vast amounts of physiological data and generate predictive insights. Algorithms can identify early warning signs of heart failure exacerbation, enabling timely intervention and potentially reducing hospitalizations.

Ethical Considerations in Cardiac Prosthetics and Transplantation

The rapid advancement of prosthetics and transplantation in cardiology raises important ethical considerations. Organ allocation remains a contentious issue, particularly given the scarcity of donor hearts and the need to balance urgency, potential benefit, and fairness. The use of expanded criteria donors and organ reconditioning techniques must be carefully weighed against the risk of transmitting disease or poor outcomes.

In the realm of prosthetics, questions arise regarding quality of life, informed consent, and the potential for overuse in cases where benefit is uncertain. For example, implantation of a VAD in

a frail elderly patient with multiple comorbidities may prolong life but may also impose a significant burden in terms of complications and lifestyle limitations.

Economic considerations also play a role, as advanced cardiac devices and transplantation involve substantial costs. Ensuring equitable access to these therapies, both within and between countries, is an ongoing challenge. Policymakers, clinicians, and patient advocates must work together to develop ethical and sustainable frameworks for technology adoption.

Pediatric Considerations in Cardiac Prosthetics and Transplantation

Cardiac diseases in children, whether congenital or acquired, pose unique challenges in transplantation and prosthetic support. Pediatric heart transplantation is the treatment of choice for many children with complex congenital heart defects or cardiomyopathies. However, the limited size of the donor pool and the technical intricacies of pediatric surgery make transplantation more complex in this population.

Ventricular assist devices for children have historically been limited by size and durability, but newer devices specifically designed for pediatric use, such as the Berlin Heart EXCOR, have shown promise. These devices can be life-saving bridges

to transplantation or recovery in young patients with acute or chronic heart failure.

Long-term follow-up, growth considerations, and the psychological impact of living with a device or transplanted organ require specialized care and multidisciplinary support. Advances in device miniaturization, biocompatibility, and remote monitoring are expected to improve outcomes and quality of life for pediatric patients.

Global Perspectives and Future Directions

Globally, the burden of cardiac disease continues to rise, particularly in low and middle income countries where access to advanced therapies is often limited. Efforts to expand organ donation programs, improve surgical training, and establish transplant infrastructure are essential to meet the growing need. International collaborations and knowledge-sharing initiatives can help disseminate best practices and support capacity building.

Looking ahead, the future of prosthetics and organ transplantation in cardiology is likely to be shaped by technological convergence. The integration of bioengineered tissues, artificial intelligence, precision medicine, and robotics will enable more personalized and effective therapies. Innovations such as fully implantable artificial hearts, bioprinted cardiac tissues, and immune

tolerance induction may one day eliminate the need for lifelong immunosuppression.

Artificial intelligence will enhance decision support, optimize device performance, and facilitate early diagnosis. Machine learning models trained on large datasets will refine risk stratification, guide therapy selection, and predict outcomes with greater accuracy. Robotics will continue to improve the precision and safety of cardiac surgeries, while 3D printing will support patient-specific modeling and device customization.

Conclusion

The advancement of prosthetics and organ transplantation for cardiac diseases represents one of the most remarkable achievements in modern medicine. These technologies have extended life and improved the quality of life for countless patients with heart failure and other life-threatening cardiac conditions. While challenges remain in terms of organ availability, device complications, and ethical considerations, ongoing research and innovation are steadily overcoming these barriers.

The future promises even greater integration of engineering, biology, and data science to create safer, smarter, and more personalized solutions. With continued investment, interdisciplinary collaboration, and a commitment to equitable

access, the potential of these life-saving technologies will continue to expand, transforming the landscape of cardiac care for generations to come.

5- ADVANCEMENT OF PROSTHETICS AND ORGAN TRANSPLANTATION FOR PULMONARY AND RESPIRATORY DISEASES

Background

Pulmonary and respiratory diseases encompass a wide range of acute and chronic conditions that impair the structure and function of the lungs and airways. These diseases include chronic obstructive pulmonary disease, cystic fibrosis, pulmonary fibrosis, severe asthma, interstitial lung disease, and acute respiratory distress syndrome. In advanced stages, these conditions can lead to irreversible lung damage, respiratory failure, and death. While pharmacological treatments, oxygen therapy, and mechanical ventilation provide temporary relief or delay progression, they do not offer permanent solutions. The emergence of prosthetic innovations and lung transplantation as therapeutic options has revolutionized the treatment landscape for patients with end-stage respiratory diseases. Over the past few decades, both fields have evolved dramatically, improving survival, restoring function, and enhancing quality of life.

Historical Background of Lung Transplantation

Lung transplantation is a relatively recent development in the field of organ transplantation. The first human lung transplant was attempted in 1963, but it was not until the 1980s that advances in surgical techniques and immunosuppressive therapy made the procedure clinically viable. Today, lung transplantation is an established treatment for end-stage lung diseases, such as idiopathic pulmonary fibrosis, cystic fibrosis, chronic obstructive pulmonary disease, and pulmonary arterial hypertension. The procedure may involve transplantation of one lung (single-lung transplant), both lungs (bilateral or double-lung transplant), or, in specific cases, a combined heart-lung transplant.

Significant improvements in donor lung preservation, organ allocation policies, and perioperative care have contributed to better outcomes. Innovations such as ex vivo lung perfusion have enabled the assessment and reconditioning of marginal donor lungs, thereby expanding the donor pool. The use of extended criteria donors and donation after circulatory death has further increased the availability of organs for transplantation. Current one-year survival rates for lung transplant recipients are over 80 percent, and many patients live ten years

or longer post-transplant.

Despite these advances, lung transplantation presents unique challenges. The lungs are continuously exposed to the external environment, making them highly susceptible to infections and immune-mediated injury. Chronic lung allograft dysfunction, particularly bronchiolitis obliterans syndrome, remains a leading cause of long-term graft failure. Lifelong immunosuppression is required to prevent rejection, which can lead to complications such as infections, malignancies, and metabolic disorders. These limitations underscore the need for continued innovation in lung transplantation and alternative approaches, such as pulmonary prosthetics and regenerative therapies.

Prosthetic Innovations in Pulmonary Medicine

Prosthetic technologies in pulmonary medicine have traditionally focused on supporting respiratory function mechanically or structurally. The development of ventilatory support systems, such as invasive and non-invasive mechanical ventilators, has been critical for managing respiratory failure. However, recent advances have extended beyond conventional ventilation to include extracorporeal membrane oxygenation, artificial lungs, and bioengineered airway structures.

Extracorporeal membrane oxygenation is a life-saving intervention for patients with severe but potentially reversible respiratory failure. ECMO provides temporary support by oxygenating blood outside the body and returning it to the circulation, allowing the lungs to rest and recover. Initially developed for neonatal care, ECMO is now widely used in adults, particularly during critical illnesses such as acute respiratory distress syndrome, pulmonary embolism, or cardiac arrest. While not a prosthetic in the traditional sense, ECMO functions as an artificial lung and is often considered a bridge to recovery or transplantation.

Artificial lungs, also known as extracorporeal lung assist devices, are more compact and long-term adaptations of ECMO technology. These devices can partially or fully replace gas exchange functions, offering potential alternatives for patients with chronic respiratory failure who are not transplant candidates. Portable artificial lung systems are under development to improve patient mobility and quality of life, potentially transforming chronic respiratory disease management.

Another area of prosthetic advancement is airway reconstruction. Tracheal stenosis, tracheomalacia, and extensive airway defects can result from congenital conditions, trauma, tumors, or prolonged intubation. Conventional surgical

techniques may be insufficient for extensive defects, leading to the development of synthetic and bioengineered airway prostheses. These include silicone stents, metallic stents, and bioresorbable scaffolds designed to restore airway patency and prevent collapse. Although stenting is a well-established technique, bioengineered constructs are emerging as a promising alternative, potentially allowing for integration with host tissue and functional regeneration.

Bioengineering and Regenerative Therapies for the Lung

Tissue engineering and regenerative medicine offer exciting opportunities to address the limitations of lung transplantation and prosthetic devices. The ultimate goal is to develop functional lung tissue capable of gas exchange, which could be used for implantation or to enhance the repair of native lung structures. The complexity of the lung, with its intricate alveolar-capillary interface, makes this task particularly challenging. Nevertheless, significant progress has been made.

One strategy involves the decellularization of donor lungs to create an acellular scaffold that retains the extracellular matrix architecture. This scaffold can then be repopulated with recipient-derived stem cells or differentiated lung cells.

Preclinical studies have demonstrated that such constructs can be perfused, ventilated, and exhibit some gas exchange capacity. While full-scale clinical application remains distant, these studies provide proof of concept and inform the development of partial lung replacements.

Another approach involves the creation of lung organoids—miniaturized and simplified versions of lung tissue grown in vitro from stem cells. These organoids recapitulate key structural and functional features of the lung and serve as platforms for disease modeling, drug testing, and regenerative research. They may also provide a source of autologous cells for future transplantation therapies.

Bioprinting technology has also entered the field, with researchers exploring the use of three-dimensional printing to construct complex lung structures layer by layer. While bioprinting entire lungs remains a long-term objective, the ability to print airway segments, alveolar units, and vascular networks has already been demonstrated in laboratory settings.

Role of Stem Cells in Pulmonary Regeneration

Stem cell therapies represent another frontier in pulmonary regeneration. Mesenchymal stem cells, derived from bone marrow, adipose tissue, or umbilical cord blood, possess anti-inflammatory,

immunomodulatory, and reparative properties. They have been tested in various clinical trials for conditions such as chronic obstructive pulmonary disease, idiopathic pulmonary fibrosis, and bronchopulmonary dysplasia. Although results have been mixed, these studies provide valuable insight into the safety and potential mechanisms of action of stem cell therapy.

Induced pluripotent stem cells, generated by reprogramming adult cells to an embryonic-like state, offer the advantage of being patient-specific, thereby reducing the risk of immune rejection. These cells can be directed to differentiate into lung-specific cell types and may be used to engineer personalized lung tissue or to study disease mechanisms.

Challenges remain in ensuring cell survival, integration, and functional contribution to lung repair. Delivery methods, dosing, and timing of administration are active areas of research. Nevertheless, stem cell therapy holds promise as an adjunct to existing treatments and as a stepping stone toward more comprehensive regenerative solutions.

Pulmonary Rehabilitation and Smart Prosthetic Devices

In addition to mechanical and biological prosthetics, the integration of smart technologies into pulmonary care is transforming

rehabilitation and long-term management. Smart inhalers, wearable sensors, and mobile health applications are enhancing the monitoring and personalization of treatment in chronic respiratory diseases.

Smart inhalers are equipped with sensors that track medication use, technique, and timing. These devices provide feedback to patients and clinicians, helping to improve adherence and optimize therapy. Wearable devices can monitor respiratory rate, oxygen saturation, heart rate, and activity levels, offering continuous data that can be analyzed using artificial intelligence algorithms to predict exacerbations and guide interventions.

Pulmonary rehabilitation programs increasingly incorporate digital platforms that allow patients to perform exercises at home while receiving real-time guidance and support. Virtual reality and gamification techniques are being explored to enhance patient engagement and motivation.

Exoskeletons and robotic devices are also being used to support respiratory muscle training and improve physical conditioning in patients with severe respiratory impairment. These technologies complement pharmacological and surgical treatments, contributing to comprehensive, patient-centered care.

Ethical and Societal

Considerations

The advancement of prosthetics and organ transplantation in pulmonary medicine raises important ethical and societal issues. Organ allocation for lung transplantation must balance medical urgency, likelihood of benefit, and fairness. Allocation systems are designed to prioritize the sickest patients, but differences in access to care, geographic disparities, and socioeconomic factors can affect outcomes.

The use of expanded criteria donors, ex vivo lung perfusion, and living lobar transplantation introduces additional ethical complexities. Informed consent, risk-benefit assessment, and transparent decision-making processes are essential to maintain public trust and ethical integrity.

Prosthetic and regenerative technologies also raise questions about access, cost, and prioritization. High-tech devices and personalized therapies may not be available in resource-limited settings, exacerbating health inequities. Policies must be developed to ensure that innovation benefits all patients, regardless of socioeconomic status.

The use of stem cells and genetically modified tissues introduces concerns about safety, long-term effects, and regulatory oversight. Ethical frameworks must evolve alongside technological progress to guide responsible research and clinical implementation.

Pediatric Applications and Special Populations

Children with congenital or acquired lung diseases present unique challenges in prosthetic and transplantation therapy. Pediatric lung transplantation is less common than in adults, largely due to the limited availability of size-matched donor organs and the technical complexities of surgery in small patients. Nevertheless, transplantation can be life-saving in conditions such as cystic fibrosis, surfactant protein deficiency, and pulmonary vascular disorders.

Prosthetic and regenerative solutions must be tailored to the growing and developing physiology of pediatric patients. Airway stents, for example, must accommodate growth and minimize trauma to delicate tissues. Tissue-engineered constructs may offer particular advantages in this population, as they can be designed to integrate and grow with the child.

Pediatric patients also require long-term follow-up and psychosocial support to manage the impact of chronic illness, invasive procedures, and lifelong medication. Multidisciplinary care teams play a critical role in optimizing outcomes and supporting families through the complex journey of treatment.

Global Health and Future Directions

Globally, respiratory diseases contribute to a significant burden of illness and death, particularly in low and middle income countries where access to advanced therapies is limited. Smoking, air pollution, occupational exposures, and infectious diseases such as tuberculosis continue to drive the global epidemic of pulmonary disease.

Efforts to expand access to lung transplantation and prosthetic technologies must include investment in infrastructure, training, and public health initiatives. International collaborations and knowledge exchange can help build capacity and disseminate best practices.

The future of prosthetics and organ transplantation for pulmonary diseases will be shaped by advances in bioengineering, artificial intelligence, genomics, and nanotechnology. Hybrid systems combining biological and mechanical components may offer new solutions for complex respiratory conditions. Personalized medicine approaches, informed by genetic and molecular profiling, will enable more targeted and effective treatments.

As technology continues to evolve, the integration of diagnostics, therapeutics, and monitoring into unified platforms will facilitate proactive,

continuous, and individualized care. The vision of restoring full pulmonary function through regenerative and prosthetic means is no longer a distant dream but an emerging reality supported by multidisciplinary science and clinical innovation.

Conclusion

The advancement of prosthetics and organ transplantation for pulmonary and respiratory diseases represents a remarkable achievement in modern medicine. These innovations have transformed the management of conditions once considered untreatable, offering renewed hope and improved quality of life for patients worldwide. From lung transplantation and artificial lungs to stem cell therapies and smart rehabilitation tools, the range of available options continues to expand.

Despite persistent challenges—such as organ shortages, immune rejection, high costs, and ethical dilemmas—the momentum of discovery and collaboration is driving the field forward. By fostering equitable access, ethical governance, and patient-centered innovation, the full potential of these life-saving technologies can be realized, reshaping the future of respiratory care for generations to come.

6- ADVANCEMENT OF PROSTHETICS AND ORGAN TRANSPLANTATION FOR OPHTHALMOLOGICAL DISEASES

Background

In recent decades, the field of ophthalmology has seen significant advancements, particularly in the areas of prosthetics and organ transplantation. These developments have brought considerable opportunities and hope to patients with various forms of vision impairment. Among the most notable advancements is corneal transplantation, a long-standing and essential procedure for treating corneal blindness. Penetrating keratoplasty (PKP), also known as optical penetrating keratoplasty (OPK), involves the full-thickness transplantation of the cornea by removing a diseased cornea and replacing it with a healthy donor corneal button. However, this method poses certain challenges, including the need for precise tissue matching and the potential for postoperative complications.

Recent innovations have led to the emergence of more refined surgical techniques such as Descemet's Membrane Endothelial Keratoplasty (DMEK) and Deep Anterior Lamellar Keratoplasty (DALK). These approaches allow for the selective

replacement of only the affected layers of the cornea, resulting in improved visual outcomes, shorter recovery periods, and a reduced risk of complications. Simultaneously, scientists have made substantial progress in the fields of bioengineering and tissue regeneration, working toward the creation of artificial or bioengineered corneas. Stem cell therapies are also being explored to reduce or eventually eliminate the reliance on donor tissues. These engineered corneas are designed to address the specific needs of individual patients and hold the potential to revolutionize current transplantation practices.

In addition to corneal advancements, prosthetic devices for retinal diseases have become increasingly effective. Conditions such as retinitis pigmentosa and age-related macular degeneration—both forms of degenerative retinal disease—frequently result in severe vision loss or total blindness. In response, retinal prosthetic devices have been developed to provide partial vision restoration for patients affected by these disorders. One example is the Argus II Retinal Prosthesis System, which enables users to regain basic visual capabilities such as detecting light and distinguishing objects. This system operates using an external camera and glasses and has proven effective in patients who have undergone prior retinal surgery.

Moreover, the Prima System, which involves

subretinal implants, represents a significant innovation in the treatment of geographic atrophy, a severe form of macular degeneration. Technologies such as these are aimed at enhancing image resolution and improving the overall quality of visual perception, especially in patients suffering from conditions like cataracts.

While total eye transplantation remains in the experimental stage, significant strides have been made. One of the major challenges lies in regenerating the optic nerve and overcoming immune rejection. Nonetheless, in 2023, a groundbreaking procedure was conducted at NYU Langone Health, involving the first successful total eye and partial face transplant—an important milestone in ophthalmic surgery. Despite this progress, achieving full functional restoration of the eye remains a complex and unresolved issue. Researchers at institutions such as Stanford University are currently engaged in collaborative efforts to regenerate the optic nerve and address these challenges.

The cumulative advancements in ophthalmic prosthetics and organ transplantation continue to generate optimism. These innovations are gradually transforming the possibilities for restoring vision and enhancing the quality of life for patients living with visual impairments. With ongoing research and interdisciplinary collaboration, the future holds great promise for

those affected by debilitating eye conditions.

The Role and Evolution of Corneal Transplantation

Among all ophthalmologic transplant procedures, corneal transplantation is the most commonly performed and the most successful. The cornea is the transparent outer layer of the eye, responsible for focusing light and maintaining visual acuity. Damage to the cornea from infection, trauma, degenerative diseases, or congenital dystrophies can lead to significant visual impairment. Corneal transplantation, also known as keratoplasty, involves replacing the damaged or diseased corneal tissue with healthy donor tissue. It has been performed successfully since the early twentieth century, and outcomes have improved dramatically with refinements in technique and postoperative care.

Penetrating keratoplasty, which involves full-thickness replacement of the cornea, was the traditional approach for many years. However, more recently, lamellar techniques such as Descemet's stripping endothelial keratoplasty and deep anterior lamellar keratoplasty have gained popularity. These procedures replace only the affected layers of the cornea, preserving healthy tissue and reducing the risk of complications. Such targeted interventions have led to faster recovery times, improved graft survival, and better visual

outcomes.

Efforts to expand the donor pool and address graft rejection have led to developments in artificial and bioengineered corneas. Artificial corneas, such as the Boston Keratoprosthesis, are used in patients who have had repeated graft failures or who are not candidates for traditional corneal transplantation. These prosthetic devices can restore vision in otherwise inoperable cases and represent a major milestone in ocular reconstruction. Research into biosynthetic corneas that integrate better with host tissue and reduce the risk of rejection continues to progress, offering a potential solution to global corneal blindness.

Retinal Prosthetics and Bionic Vision Systems

Retinal degenerative diseases, including retinitis pigmentosa and age-related macular degeneration, result in the progressive loss of photoreceptor cells, leading to severe vision impairment and ultimately blindness. Retinal prosthetics, also known as bionic eyes or retinal implants, have emerged as a revolutionary approach to partially restore visual function in patients with these conditions. These devices are designed to bypass the damaged photoreceptors and directly stimulate the remaining retinal cells or the optic nerve.

One of the earliest and most widely studied retinal prostheses is the Argus II system. This device consists of a small camera mounted on glasses that captures visual information and sends it to a processing unit. The processed signals are then transmitted wirelessly to an implant on the retina, which stimulates the inner retinal cells to evoke visual percepts. While the resolution of these devices is currently limited, they allow patients to perceive light, motion, and basic shapes, greatly enhancing mobility and independence.

Other systems, such as the Alpha AMS subretinal implant and the PRIMA system, aim to provide higher resolution and better integration with the retinal architecture. The subretinal placement of the implant allows for more natural visual processing by utilizing the remaining neural circuitry of the retina. These devices have shown promise in clinical trials and continue to evolve with improvements in electrode density, biocompatibility, and power supply systems.

In addition to epiretinal and subretinal implants, researchers are exploring optic nerve and cortical prostheses that stimulate the visual cortex directly. These approaches may benefit patients with damage to the retina or optic nerve. Though still largely experimental, these systems represent the future frontier of bionic vision and neural interfacing.

Ocular Surface and Conjunctival Reconstruction

Beyond the cornea and retina, diseases affecting the ocular surface and conjunctiva can also result in significant visual morbidity and discomfort. Conditions such as Stevens-Johnson syndrome, ocular cicatricial pemphigoid, and severe chemical burns can lead to conjunctival scarring, limbal stem cell deficiency, and symblepharon formation. In such cases, reconstruction using prosthetic materials or tissue transplantation is often necessary.

Limbal stem cell transplantation has emerged as a pivotal therapy for restoring the integrity of the ocular surface. Limbal stem cells are responsible for regenerating the corneal epithelium and maintaining transparency. In patients with unilateral limbal deficiency, autologous limbal grafts from the healthy eye can restore function. In bilateral cases, allogeneic transplantation from a donor or the use of cultivated stem cell sheets may be employed.

Amniotic membrane transplantation is another important technique for ocular surface reconstruction. The amniotic membrane, harvested from placental tissue, has anti-inflammatory, anti-scarring, and pro-regenerative properties. It can be used as a scaffold for epithelial growth or as a temporary patch in acute injuries.

Its application has improved outcomes in a wide range of surface disorders.

Synthetic conjunctival substitutes and scaffolds are also being developed to replace damaged tissue and facilitate healing. Advances in tissue engineering and biomaterials are enhancing the biocompatibility, durability, and functional performance of these prosthetic solutions.

Orbital Implants and Ocular Prostheses

In cases of trauma, malignancy, or intractable ocular disease, enucleation or evisceration of the eye may be necessary. These procedures, while life-saving or pain-relieving, result in significant cosmetic and functional deficits. Orbital implants and ocular prostheses play a vital role in restoring appearance, supporting eyelid mechanics, and improving psychosocial well-being.

Orbital implants are typically spherical devices placed within the orbit to replace the volume lost after eye removal. Materials such as porous polyethylene, hydroxyapatite, and silicone are commonly used. These implants are often coupled with a motility peg that allows the prosthetic eye to move in coordination with the contralateral eye.

Ocular prostheses are custom-made external shells that replicate the appearance of a natural

eye. Advances in materials, color-matching techniques, and fabrication methods have made these prostheses highly realistic and comfortable. The integration of digital technology into the design process, such as 3D scanning and printing, has further improved fit and personalization.

Psychological support and rehabilitation are essential components of care for patients receiving ocular prostheses. Specialized ophthalmologists, prosthodontists, and mental health professionals collaborate to optimize outcomes and address the emotional impact of eye loss.

Advances in Whole Eye Transplantation and Optic Nerve Regeneration

Whole eye transplantation has long been considered the holy grail of ocular surgery. The concept involves replacing the entire eye, including its neural connections, to restore sight in cases of complete ocular and optic nerve destruction. Although this remains an experimental and technically formidable procedure, recent developments have brought the idea closer to reality.

In 2023, a team at NYU Langone Health performed the world's first human whole eye transplant in conjunction with a partial face transplant. While the patient did not regain vision, the surgery demonstrated the feasibility of vascular and

structural integration. This milestone has inspired further research into immunological tolerance, neuroregeneration, and functional restoration.

A major barrier to successful whole eye transplantation is the regeneration of the optic nerve. Unlike peripheral nerves, the optic nerve is part of the central nervous system and has limited regenerative capacity. Researchers are exploring gene therapy, stem cell transplantation, and bioengineered conduits to promote axonal growth and reconnection with the brain's visual centers.

Optogenetics, a technique that uses light-sensitive proteins to restore photosensitivity in retinal cells, is also being investigated as a means to bypass damaged pathways. Combined with visual prosthetics or transplanted photoreceptors, these methods hold potential for restoring visual perception in previously untreatable cases.

Gene Therapy and Cellular Reprogramming

Gene therapy has emerged as a transformative tool in ophthalmology, particularly for inherited retinal diseases. The approval of voretigene neparvovec, a gene therapy for RPE65-related retinal dystrophy, marked a historic achievement. Delivered via subretinal injection, the therapy introduces a functional copy of the defective gene, restoring visual function in affected individuals.

Ongoing clinical trials are investigating gene therapies for a range of genetic eye conditions, including choroideremia, X-linked retinitis pigmentosa, Stargardt disease, and Leber congenital amaurosis. The use of viral and non-viral vectors, as well as genome editing technologies like CRISPR, are being refined for safety, specificity, and efficacy.

Cellular reprogramming involves converting one type of cell into another, such as turning fibroblasts into retinal neurons. This approach offers the possibility of regenerating lost photoreceptors or retinal ganglion cells from a patient's own cells, thereby minimizing immune rejection. The ability to generate autologous retinal cells from induced pluripotent stem cells has significant implications for both transplantation and disease modeling.

Smart Implants and Digital Integration

With the rise of wearable and implantable technologies, the integration of smart devices into ocular care is becoming increasingly sophisticated. Smart contact lenses equipped with sensors can monitor intraocular pressure in glaucoma patients, track glucose levels in diabetic patients, or deliver medications in a controlled manner.

Implantable microelectronic sensors can provide

real-time feedback on ocular health parameters and communicate data wirelessly to healthcare providers. These devices enable continuous monitoring and early detection of complications, allowing for proactive management and reducing the need for frequent clinic visits.

Augmented reality and virtual reality systems are also being developed for vision enhancement and rehabilitation. These platforms can assist individuals with low vision in navigation, object recognition, and reading. Combined with artificial intelligence and machine learning algorithms, smart technologies are transforming the way visual disability is managed and understood.

Ethical Considerations and Global Access

As prosthetic and transplant technologies advance, ethical considerations must be addressed. The use of genetically modified cells, donor tissues, and invasive devices raises questions about consent, long-term safety, and equitable access. Regulatory frameworks must keep pace with innovation to ensure that new treatments are introduced responsibly and ethically.

Access to advanced ophthalmologic care remains a significant global challenge. In many low and middle income countries, the burden of preventable blindness is high, while resources

for corneal transplantation, ocular prosthetics, or gene therapy are scarce. Initiatives to expand eye banking, provide training, and invest in affordable technologies are essential to bridge this gap.

Efforts to ensure inclusivity, cultural sensitivity, and affordability will be key to realizing the full potential of these advancements. Collaboration between governments, research institutions, non-governmental organizations, and industry will be critical in making vision-restoring technologies accessible to all.

Conclusion

The advancement of prosthetics and organ transplantation for ophthalmological diseases has ushered in a new era of hope for individuals with visual impairment and blindness. From corneal transplants and retinal prostheses to gene therapy and bioengineered tissues, the possibilities for restoring sight are expanding rapidly. These innovations not only improve visual function but also enhance independence, dignity, and quality of life for millions of patients worldwide.

While challenges remain—particularly in the areas of optic nerve regeneration, long-term integration of prosthetics, and global accessibility—the trajectory of progress is promising. Multidisciplinary collaboration, ethical stewardship, and patient-centered care will be essential in ensuring that the benefits

of these technologies are realized equitably and sustainably.

The future of vision restoration lies at the intersection of biology, engineering, and digital technology. As these fields continue to converge, the dream of reversing blindness and preserving sight is no longer a distant aspiration, but an achievable goal grounded in scientific rigor and compassionate innovation.

7- ADVANCEMENT OF PROSTHETICS AND ORGAN TRANSPLANTATION FOR ORAL DISEASES

Background

Oral health is integral to general health, affecting nutrition, communication, social interaction, and overall well-being. Oral diseases, ranging from congenital anomalies and trauma to infections, tumors, and systemic conditions, can result in significant tissue loss, functional impairment, and disfigurement. While preventive strategies and conservative treatments are cornerstones of oral healthcare, advanced diseases often require surgical intervention and restorative techniques to rehabilitate lost structures. Over recent decades, advancements in prosthetics and organ transplantation have significantly transformed the management of complex oral conditions. The integration of biomaterials, digital technologies, regenerative medicine, and microsurgical techniques has made it possible to restore form and function to an unprecedented degree. These innovations have enhanced the quality of life for patients affected by oral cancers, craniofacial deformities, maxillofacial trauma, and systemic conditions with oral manifestations.

Dental Prosthetics and Maxillofacial Rehabilitation

Dental prosthetics form the foundation of restorative dentistry, encompassing a wide array of devices that replace missing teeth and associated oral structures. These include complete and partial dentures, crowns, bridges, and dental implants. Traditional removable dentures, although still widely used, have evolved significantly in terms of materials, aesthetics, and comfort. Contemporary dentures are fabricated using lightweight, biocompatible resins and are designed for precise anatomical fit. They restore basic functions such as mastication and speech while providing esthetic satisfaction.

Fixed prosthodontics, including crowns and bridges, offer durable and esthetically pleasing solutions for tooth replacement. With the advent of computer-aided design and computer-aided manufacturing (CAD/CAM) technologies, prosthetic devices can be digitally designed and fabricated with high accuracy. Materials such as zirconia, lithium disilicate, and high-strength ceramics have replaced traditional metal-based restorations, offering enhanced strength, biocompatibility, and aesthetics.

Implant-supported prosthetics represent a significant advancement in oral rehabilitation. Dental implants, typically made from titanium or

zirconia, are surgically placed into the jawbone to serve as artificial roots. They provide a stable foundation for fixed or removable prostheses and promote bone preservation through load transfer. Innovations in implant design, surface modification, and immediate loading protocols have improved success rates and reduced treatment times. Implant dentistry now plays a central role in the rehabilitation of edentulous patients, especially in the elderly population and those with complex maxillofacial defects.

Craniofacial and Maxillofacial Prosthetics

Craniofacial prosthetics extend beyond dental restoration to address defects involving the face, jaws, and oral cavity. These prostheses are typically used in cases of congenital deformities, trauma, or surgical resection due to cancer. Maxillofacial prosthodontists work closely with head and neck surgeons, oncologists, and speech therapists to design devices that restore appearance, function, and psychosocial well-being.

Obturators are used to close palatal defects resulting from maxillectomy or congenital clefts. These prostheses restore speech and swallowing by separating the oral and nasal cavities. Surgical obturators are often placed immediately after surgery to aid in healing and function, followed

by definitive obturators once tissue healing is complete.

Mandibular and facial prostheses are used to reconstruct extensive tissue loss resulting from trauma or tumor resection. Auricular, nasal, and orbital prostheses, often retained using osseointegrated implants or adhesives, are custom-designed to match the patient's anatomy and skin tone. Advances in anaplastology, digital scanning, and 3D printing have improved the fabrication process and esthetic outcomes of these devices.

The psychological impact of facial disfigurement is profound, and maxillofacial prosthetics play a critical role in restoring identity and confidence. The integration of prosthetic rehabilitation with psychosocial support services is essential for holistic patient care.

Oral and Maxillofacial Transplantation

Organ transplantation in the context of oral diseases is a relatively new but rapidly evolving field. Composite tissue allotransplantation, also known as vascularized composite allotransplantation, involves the transfer of multiple tissue types, including skin, muscle, bone, nerves, and mucosa, as a functional unit. In the realm of oral and maxillofacial surgery, facial transplantation has emerged as a groundbreaking

intervention for patients with devastating facial injuries or defects that cannot be reconstructed with traditional techniques.

The first partial face transplant was performed in France in 2005, followed by several full face transplants in the United States, Spain, and other countries. These procedures restore not only facial appearance but also oral functions such as speech, chewing, breathing, and sensation. Facial transplantation involves complex microsurgery to connect blood vessels, nerves, and bony structures, followed by lifelong immunosuppression to prevent rejection.

While the outcomes of facial transplantation are remarkable, the procedure remains ethically and logistically complex. Donor availability, immunological challenges, psychological adaptation, and the risk of chronic rejection are significant considerations. Nevertheless, facial transplantation represents one of the most significant advancements in the rehabilitation of severe oral and facial defects.

Bone Grafting and Osseous Reconstruction

Reconstruction of the maxillofacial skeleton is essential for functional and esthetic rehabilitation in patients with large osseous defects due to trauma, infection, tumors, or congenital conditions. Autogenous bone grafts, harvested

from intraoral or extraoral donor sites, have long been considered the gold standard due to their osteogenic potential and biocompatibility. Common donor sites include the iliac crest, fibula, scapula, and mandibular symphysis.

The free fibula flap is a workhorse in mandibular reconstruction, providing ample bone for contouring and implant placement. Vascularized bone flaps offer superior integration and resistance to infection, making them suitable for irradiated or compromised tissues. Technological advancements in virtual surgical planning, stereolithographic modeling, and patient-specific cutting guides have enhanced the precision and predictability of reconstructive surgeries.

Alloplastic materials and bone substitutes, such as hydroxyapatite, beta-tricalcium phosphate, and bioactive glass, are also used to restore osseous defects. These materials can be combined with growth factors or stem cells to enhance bone regeneration. While not suitable for all cases, they offer a viable alternative when autografts are not feasible or desirable.

Distraction osteogenesis is another technique used to promote new bone formation by gradually separating bone segments after an osteotomy. This method is particularly useful in pediatric patients and in cases of severe hypoplasia or asymmetry.

Soft Tissue Reconstruction and Mucosal Grafting

Soft tissue reconstruction of the oral cavity is essential for restoring speech, swallowing, and mastication. Techniques range from local flaps and skin grafts to microvascular free tissue transfer. The radial forearm free flap is widely used for intraoral reconstruction due to its thin, pliable skin and reliable vascularity. It is particularly useful for defects of the tongue, floor of mouth, and buccal mucosa.

Other commonly used flaps include the anterolateral thigh flap, latissimus dorsi flap, and submental flap. These flaps can be tailored in thickness and volume to match the defect and functional requirements. Muscle flaps may be used to fill dead space, while mucosal grafts are preferred for lining surfaces that require mobility and moisture.

Advances in microsurgical techniques, vascular imaging, and flap monitoring have improved the safety and outcomes of soft tissue reconstruction. Tissue engineering approaches, including the use of cell-seeded scaffolds and bioprinted mucosa, are under investigation as potential alternatives to autologous grafts.

Regenerative Dentistry and Stem Cell Therapies

Regenerative dentistry aims to restore the form and function of oral tissues using biologically based therapies. This field has witnessed rapid progress, driven by advances in stem cell biology, biomaterials, and molecular signaling pathways. Dental stem cells, such as dental pulp stem cells, periodontal ligament stem cells, and stem cells from apical papilla, have demonstrated potential for regenerating dentin, pulp, periodontal ligament, and alveolar bone.

Pulp regeneration using scaffolds and growth factors has shown promise in immature teeth with necrotic pulps. Clinical protocols involving disinfection, blood clot induction, and stem cell recruitment have been developed to regenerate functional pulp tissue capable of continued root development and sensory response.

Periodontal regeneration focuses on restoring the complex structure of the periodontium, including the cementum, periodontal ligament, and alveolar bone. Guided tissue regeneration, use of enamel matrix derivatives, and application of platelet-rich fibrin are common regenerative techniques. Emerging therapies aim to harness stem cells and bioactive molecules to achieve more predictable and complete regeneration.

Bone tissue engineering involves the use of scaffolds, cells, and signaling molecules to reconstruct alveolar bone for implant placement or defect repair. Biodegradable scaffolds, often

composed of collagen, polylactic acid, or ceramics, provide a framework for cell attachment and new tissue formation. Growth factors such as bone morphogenetic proteins enhance osteogenesis and angiogenesis.

Salivary gland regeneration is another area of interest, particularly for patients with xerostomia due to radiation therapy or autoimmune diseases. Stem cell transplantation and gene therapy are being explored to restore glandular function and improve quality of life.

Digital Dentistry and Prosthetic Fabrication

The integration of digital technology into prosthetic dentistry has revolutionized treatment planning, design, and fabrication. Intraoral scanners allow for accurate, non-invasive capture of dental arches, eliminating the need for traditional impressions. Digital design software enables precise modeling of prostheses, which can be manufactured using 3D printing or milling technologies.

CAD/CAM technology facilitates the production of crowns, bridges, dentures, and implant abutments with superior accuracy and fit. This reduces chair time, improves patient comfort, and enhances esthetic outcomes. Digital workflows also allow for virtual articulation, occlusal analysis, and simulation of prosthetic function.

Three-dimensional printing has expanded the possibilities for custom prostheses, surgical guides, and educational models. Materials such as photopolymer resins, metals, and ceramics can be used to produce high-quality restorations. Personalized medicine approaches are emerging, where genetic, anatomic, and functional data are used to tailor prosthetic solutions to individual patient needs.

Ethical and Accessibility Considerations

As prosthetic and transplant technologies evolve, ethical considerations must be addressed. Informed consent, patient selection, and management of expectations are crucial in procedures with high risk and complex outcomes. Facial transplantation, in particular, involves extensive psychological evaluation, as the procedure affects identity, self-image, and social interaction.

Access to advanced oral rehabilitation remains a challenge in many parts of the world. Dental prosthetics, implant therapy, and reconstructive surgery may be unaffordable or unavailable to underserved populations. Efforts to improve training, infrastructure, and insurance coverage are needed to bridge these gaps.

The use of human tissues and stem cells raises additional ethical questions related to sourcing,

consent, and long-term safety. Regulatory frameworks must evolve to ensure responsible innovation and patient protection.

Conclusion

The advancement of prosthetics and organ transplantation for oral diseases represents a remarkable convergence of science, technology, and clinical expertise. These innovations have transformed the lives of individuals affected by complex oral conditions, offering restoration of function, esthetics, and dignity. From dental implants and craniofacial prosthetics to tissue-engineered grafts and facial transplants, the spectrum of available treatments continues to expand.

Future directions include the integration of regenerative medicine, digital technology, and personalized care to create more effective, efficient, and accessible solutions. Multidisciplinary collaboration, ethical stewardship, and global equity will be essential in realizing the full potential of these life-changing therapies. As research and innovation continue to evolve, the dream of fully restoring oral health in even the most challenging cases is steadily becoming a clinical reality.

8- ADVANCEMENT OF PROSTHETICS AND ORGAN TRANSPLANTATION FOR ENT DISEASES

Background

Individuals with hearing, speech, and structural abnormalities in the field of otolaryngology (ENT) have experienced significant improvements in their quality of life due to advances in organ transplantation and prosthetic technologies. The management of congenital, traumatic, and ENT-related disorders has been transformed by the development of cochlear implants, bone-anchored hearing aids (BAHA) prostheses, 3D-printed laryngeal and tracheal constructs, and vascularized composite allograft (VCA) transplantation. In addition, progress in larynx and trachea transplantation has offered new treatment options for severe abnormalities resulting from airway obstruction, cancer, and degenerative diseases. One of the most sophisticated prosthetic innovations in the ENT field is the cochlear implant, which has restored hearing for thousands of individuals with sensorineural hearing loss (SNHL). Since the experimental introduction of cochlear implants in the 1970s, these devices have significantly

enhanced speech comprehension and communication by employing advanced audio processing and neural stimulation to replicate natural hearing. Beyond hearing restoration, laryngeal and tracheal prostheses have evolved for rehabilitative use in patients suffering from voice loss following laryngectomy, vocal cord paralysis, and airway stenosis. A notable example is the Blom-Singer voice prosthesis, which enables speech in laryngectomy patients by channeling air from the lungs into the esophagus through a one-way valve, facilitating sound production. For patients with extensive airway damage, new solutions have been pioneered through the application of 3D printing technologies to design bioengineered laryngeal scaffolds and tissue-engineered tracheal grafts. A major milestone in airway reconstruction was the first successful human laryngeal transplant in 1998, which enabled a patient with a laryngeal injury to regain the ability to speak and swallow. Since that time, improvements in VCA transplantation and immunosuppressive therapy have enhanced graft survival and functional outcomes. Tracheal transplantation has also emerged as a viable option for individuals with airway collapse or long-segment tracheal stenosis. Modern approaches employing stem-cell-based tissue engineering and decellularized donor tracheas have yielded promising results, overcoming challenges seen in earlier attempts that were

limited by inadequate vascularization and graft rejection. Facial transplantation represents another transformative advancement in ENT surgery, successfully implemented in patients with severe facial trauma, burns, and congenital deformities. The first partial face transplant was performed in 2005, followed by several full face transplants in subsequent years, significantly improving both functional and aesthetic outcomes for recipients. The innovations in modern prosthetics and organ transplantation have revolutionized the management of ENT diseases, allowing for superior restoration and enhanced quality of life in patients with impairments in hearing, speech, and airway function. Continued research in tissue engineering, immunotherapy, and bioengineering is driving further advancements and offering hope for even greater outcomes in the future.

Organ donation and prosthetics have made significant strides in the field of otolaryngology, transforming the management of serious ENT disorders that once left individuals permanently unable to speak, hear, breathe, or express facial movement. These advances have not only improved clinical outcomes but also remarkably enhanced the quality of life for patients affected by diseases of the ear, nose, and throat.

Historically, patients suffering from ENT disorders such as profound hearing loss, laryngeal

damage, extensive facial trauma requiring fasciotomy, and tracheal stenosis had limited therapeutic options. This lack of effective treatment often led to lifelong disability and functional impairments. However, recent years have witnessed the emergence of innovative medical solutions—including prosthetic implants and organ transplants—that are both life-saving and function-restoring for individuals with complex ENT conditions. Hearing loss, particularly sensorineural deafness caused by hereditary factors, aging, infections, or prolonged noise exposure, is one of the most common ENT-related challenges. For those who do not benefit from conventional hearing aids, alternatives such as cochlear implants and bone-anchored hearing aids have been developed. These devices work by directly stimulating the auditory nerve or transmitting sound through bone conduction, thereby restoring the ability to perceive sounds and communicate effectively. In parallel with advancements in auditory prosthetics, substantial progress has also been made in laryngeal transplantation. Once considered unfeasible due to concerns over functional preservation and immune rejection, successful human laryngeal transplants have now been achieved. These procedures have restored speech and respiratory function in patients with severe laryngeal trauma or congenital abnormalities. Improvements in surgical techniques and immunosuppressive

therapy have led to increased graft survival, enabling laryngeal transplantation to become a viable real-world treatment option. Previously, tracheal transplantation was hindered by challenges related to poor vascularization. Today, through the use of decellularized donor tracheas and tissue-engineered scaffolds, it is possible to develop biocompatible replacements that integrate more effectively with host tissues. The fusion of regenerative medicine with 3D bioprinting has revolutionized prosthesis development for ENT patients, particularly in reconstructive procedures involving the nose and ears. Bioengineered cartilage grafts have reduced the need for rib cartilage autografts, simplifying surgical interventions and improving outcomes. The application of 3D-printed prostheses—customized for individual anatomical structures and enhanced for biocompatibility—has significantly advanced facial reconstruction, improving both appearance and function. Moreover, the integration of bioresorbable scaffolds embedded with growth factors has enabled more natural tissue regeneration, reducing dependence on synthetic implants for ENT repair. Despite these remarkable advancements, challenges remain, including long-term graft survival, the risk of immune rejection, and the durability of prosthetic materials. The future of ENT surgery will likely be shaped by bionically engineered tissues, organ

transplantation, advanced prosthetic technologies, artificial intelligence-driven rehabilitation systems, and minimally invasive surgical techniques. Collaborative, interdisciplinary efforts among biomedical engineers, otolaryngologists, and transplantation specialists will be essential to refining these innovations and ensuring that patients with ENT disorders receive the most effective and comprehensive care possible.

Cochlear and Auditory Prostheses

Among the most celebrated achievements in ENT prosthetics is the development of cochlear implants. Designed to restore hearing in individuals with profound sensorineural deafness, these electronic devices bypass damaged hair cells in the cochlea and directly stimulate the auditory nerve. The result is a functional sense of hearing for patients who otherwise could not benefit from conventional hearing aids. Cochlear implants consist of an external component that captures and processes sound, and an internal component that delivers electrical impulses to the auditory nerve via a surgically implanted electrode array.

The first cochlear implants were introduced in the 1970s, and since then, the technology has undergone remarkable evolution. Modern devices

provide improved frequency resolution, greater speech recognition in noisy environments, and compatibility with wireless technologies such as smartphones and assistive listening devices. Pediatric implantation, now widely accepted as the standard of care for children born with severe hearing loss, supports language development and social integration during early childhood.

Auditory brainstem implants are another class of hearing prostheses, developed for patients with non-functioning auditory nerves or absence of the cochlea, such as those with neurofibromatosis type II. These devices stimulate the cochlear nucleus in the brainstem and are used when cochlear implants are not viable. Although outcomes are generally less robust than those of cochlear implants, advancements in surgical targeting and signal processing are improving performance.

Middle ear implants and bone-anchored hearing aids further expand the repertoire of auditory prosthetics. Middle ear implants are suitable for patients with mixed or conductive hearing loss and function by mechanically stimulating the ossicular chain. Bone-anchored hearing aids transmit sound vibrations through the skull directly to the inner ear, bypassing the external and middle ear. These devices have proven effective in patients with chronic otitis media, atresia, or single-sided deafness.

Laryngeal and Tracheal Protheses

Loss of laryngeal function, often due to laryngectomy for cancer or trauma, profoundly impacts phonation, swallowing, and airway protection. The development of voice protheses has provided patients with a means to regain verbal communication following total laryngectomy. The most common form of voice rehabilitation is the tracheoesophageal puncture technique, wherein a one-way silicone valve is inserted between the trachea and esophagus. This allows air to pass into the esophagus during exhalation, generating sound that is modulated into speech by the oral cavity and tongue.

The Blom-Singer and Provox protheses are widely used voice prosthetic devices, offering improved durability, hygiene, and speech quality. Patients require routine follow-up to assess valve function and prevent complications such as leakage or biofilm accumulation. Recent innovations include heat and moisture exchangers integrated into the prosthesis, which improve pulmonary function by conditioning inhaled air.

Tracheal protheses and stents are utilized in patients with tracheal stenosis, collapse, or resection defects. These devices help maintain airway patency and support normal respiration. Silicone and metallic stents are commonly

employed, although long-term use can lead to complications such as granulation tissue formation, migration, or infection. Bioengineered tracheal replacements are currently under investigation and involve the use of synthetic scaffolds seeded with autologous stem cells. Preliminary clinical trials have demonstrated the feasibility of constructing functional, vascularized tracheal grafts, but challenges remain in achieving full integration and long-term durability.

Facial Prosthetics and Osseointegrated Devices

Facial deformities due to congenital anomalies, trauma, infection, or oncologic resection can have a profound impact on a patient's psychological well-being and social integration. In cases where surgical reconstruction is not feasible or does not provide satisfactory results, prosthetic rehabilitation offers a viable alternative. Facial protheses are custom-designed to replace absent or disfigured anatomical features, including the nose, ears, and orbital contents.

Modern facial protheses are fabricated from medical-grade silicone, which can be tinted to match the patient's skin tone and texture. Advanced imaging and 3D printing technologies are now used to design protheses with high precision and anatomical accuracy.

Retention methods include adhesives, glasses, and osseointegrated implants. The latter involve titanium posts anchored into bone, providing a stable foundation for magnetically or mechanically attached prostheses.

Orbital prostheses are used following enucleation, evisceration, or exenteration, and typically include both a conformer to fill the orbital cavity and an external prosthetic eye. Prosthetic eyes can be remarkably lifelike and contribute significantly to a patient's appearance and self-esteem. Similarly, auricular prostheses are used when ear reconstruction is contraindicated or has failed. These devices are often indistinguishable from natural ears and allow patients to wear glasses or hearing aids.

Nasal prostheses are more challenging due to the complexity of nasal anatomy and airflow requirements. However, with careful design and fit, they can provide both esthetic restoration and functional nasal patency.

Facial Transplantation and Composite Tissue Allotransplantation

For patients with extensive facial injuries or defects that cannot be adequately addressed with prosthetics or autologous reconstruction, facial transplantation has emerged as a groundbreaking therapeutic option. Facial transplantation is

a form of vascularized composite tissue allotransplantation, involving the transfer of skin, muscle, bone, nerves, and blood vessels from a donor to a recipient.

The first partial face transplant was performed in 2005, and since then, full-face transplants have been successfully carried out in multiple countries. These complex procedures require meticulous microsurgery to anastomose vessels and nerves, followed by a lifetime of immunosuppressive therapy. Outcomes vary depending on the extent of the transplant, immunologic response, and postoperative rehabilitation, but many patients achieve significant restoration of facial appearance and function, including sensation, movement, and speech.

Candidates for facial transplantation undergo extensive psychological evaluation to ensure their ability to cope with the profound changes associated with the procedure. Ethical considerations include donor consent, identity transformation, and access to long-term care. Despite these challenges, facial transplantation represents the pinnacle of reconstructive surgery, offering transformative results for patients with devastating facial injuries.

Olfactory and Gustatory Prosthetics

While much attention in ENT prosthetics has focused on hearing and speech, recent research has begun to explore the restoration of smell and taste. Loss of olfaction, whether due to trauma, infection, or neurodegenerative disease, can significantly impair quality of life and safety. While a true olfactory prosthesis remains in the experimental phase, studies have investigated the use of direct electrical stimulation of the olfactory bulb or cortex to evoke smell perception.

Analogous to cochlear implants, olfactory implants would detect airborne molecules using sensors and convert them into electrical signals transmitted to neural pathways. Challenges include the complexity of olfactory coding, individual variability, and the integration of synthetic perception into conscious experience. Similar research is underway for gustatory prostheses, which would stimulate taste receptors or nerves to recreate flavor sensations in patients with dysgeusia or ageusia.

Although these fields are still in their infancy, the potential for restoring chemical senses opens new dimensions in sensory rehabilitation and illustrates the breadth of prosthetic applications within ENT care.

***Advances in Regenerative
Medicine and Tissue
Engineering***

The emergence of regenerative medicine has had a profound impact on ENT surgery and prosthetics. Tissue-engineered grafts are being developed for a variety of applications, including tympanic membrane repair, nasal septum reconstruction, laryngeal cartilage replacement, and tracheal regeneration. These constructs often consist of biocompatible scaffolds seeded with autologous cells and bioactive molecules that promote tissue integration and healing.

One notable example is the development of bioengineered vocal fold tissue, which aims to restore phonation in patients with vocal fold scarring or loss. By replicating the layered structure and viscoelastic properties of native vocal folds, researchers have created constructs capable of vibratory function and sound production.

In tympanoplasty, acellular dermal matrices and collagen scaffolds are being used to repair perforated eardrums with improved outcomes and faster healing. Similar materials are being applied in nasal reconstruction and sinus surgery to support mucosal regeneration and minimize fibrosis.

Stem cell therapy is also being explored for sensorineural hearing loss, with the goal of regenerating hair cells in the cochlea. While clinical translation is ongoing, preclinical studies have demonstrated the potential for stem cell-

derived progenitors to integrate into the cochlear architecture and restore auditory function.

Implantable Airway and Sinus Devices

Implantable devices designed to improve airflow and sinus drainage have gained popularity in the treatment of chronic rhinosinusitis and obstructive sleep apnea. Biodegradable sinus stents coated with corticosteroids are now commonly used after endoscopic sinus surgery to reduce inflammation, prevent adhesions, and promote healing. These devices gradually dissolve over weeks, eliminating the need for removal and reducing the risk of complications.

For patients with nasal valve collapse or dynamic obstruction, absorbable implants made from polylactide materials are used to support lateral nasal walls. These implants offer a minimally invasive solution with minimal downtime and high patient satisfaction.

In obstructive sleep apnea, hypoglossal nerve stimulators represent an innovative alternative to continuous positive airway pressure therapy. These devices are implanted in the chest and deliver electrical stimulation to the hypoglossal nerve during sleep, preventing airway collapse. Clinical studies have demonstrated improvements in apnea-hypopnea index, oxygen saturation, and quality of life in appropriately selected patients.

Ethical and Societal Considerations

As prosthetics and organ transplantation for ENT diseases become increasingly advanced, ethical considerations must keep pace with technological progress. The allocation of donor tissues, informed consent, access disparities, and the psychological impact of transformative procedures are central to responsible clinical practice.

Facial transplantation, in particular, raises profound questions about identity, privacy, and long-term well-being. Recipients must adapt to a new facial appearance, manage the burden of immunosuppression, and navigate complex social reintegration. Ensuring informed, voluntary consent and comprehensive psychosocial support are critical components of care.

Access to advanced ENT prosthetics is often limited by cost, availability, and healthcare infrastructure. Global disparities in access to cochlear implants, surgical expertise, and rehabilitation services highlight the need for policy initiatives that promote equity and inclusion. Research and development efforts should prioritize not only innovation but also scalability and affordability.

Public engagement and education are essential to foster understanding and acceptance of novel

treatments. Cultural sensitivities surrounding tissue donation and facial transplantation must be addressed through transparent communication and community involvement.

Conclusion

The advancement of prosthetics and organ transplantation in ENT medicine exemplifies the transformative potential of modern medical science. From restoring hearing with cochlear implants to reconstructing entire faces through transplantation, these interventions offer renewed function, identity, and hope to individuals with severe ENT disorders. The integration of digital technologies, regenerative medicine, and personalized care continues to expand the frontiers of what is possible in sensory and structural rehabilitation.

As these innovations progress, a commitment to ethical practice, equitable access, and multidisciplinary collaboration will be essential to ensure that their benefits reach all who need them. The ongoing evolution of ENT prosthetics and transplantation not only enhances clinical outcomes but also reaffirms the profound human aspiration to overcome physical limitations and reclaim the essence of communication, expression, and interaction.

9- ADVANCEMENT OF PROSTHETICS AND ORGAN TRANSPLANTATION FOR ORTHOPEDIC DISEASES

Background

Orthopedic diseases encompass a broad spectrum of disorders that affect bones, joints, muscles, ligaments, and tendons. These conditions range from congenital anomalies and traumatic injuries to degenerative diseases such as osteoarthritis and osteoporosis. In their most severe forms, orthopedic conditions can lead to significant pain, disability, and loss of function, greatly impairing an individual's quality of life. While pharmacological management and physiotherapy provide relief in early stages, many cases ultimately require surgical intervention and long-term reconstructive solutions. In recent decades, prosthetic advancements and musculoskeletal tissue transplantation have transformed the treatment landscape of orthopedic diseases. The integration of mechanical engineering, biomaterials, regenerative medicine, robotics, and digital technologies has enabled clinicians to restore mobility, preserve independence, and improve long-term outcomes for patients with complex musculoskeletal disorders.

The Evolution of Orthopedic Prosthetics

The concept of orthopedic prosthetics dates back thousands of years, with early examples of wooden legs and metal limbs used by injured warriors. Modern prosthetics, however, have undergone a revolutionary transformation driven by advancements in materials science, biomechanics, and user-centered design. Today's prosthetic limbs are not only functional but increasingly lifelike, lightweight, and responsive to the user's intent.

Lower limb prosthetics are among the most widely used and have seen significant innovation. Prosthetic feet and knees now incorporate microprocessor-controlled joints and hydraulic systems that adapt to terrain and gait patterns in real-time. These smart prosthetics provide a more natural walking experience and reduce the energy expenditure required for ambulation. Powered exoskeletal systems, initially developed for rehabilitation purposes, are now being refined for daily use, enabling individuals with lower limb paralysis to stand and walk independently.

Upper limb prosthetics have traditionally been more challenging due to the complexity of hand and finger movements. However, recent breakthroughs in myoelectric control systems, which use electrical signals from residual

muscles, have allowed for the development of multi-articulated prosthetic hands capable of grasping, pinching, and rotating. Some devices are equipped with sensors that provide sensory feedback, allowing users to feel pressure and texture, enhancing their interaction with the environment. Bionic arms, such as the LUKE arm and the DEKA arm, exemplify the high level of integration possible between neural signals and mechanical components.

The emergence of 3D printing technology has also impacted the field of prosthetics. Custom prosthetic sockets and limbs can now be produced with precision and efficiency, improving fit and comfort while reducing manufacturing costs. This democratization of prosthetic production holds particular promise for low-resource settings where access to advanced medical devices is limited.

Joint Replacement and Arthroplasty Innovations

Joint diseases, particularly osteoarthritis and rheumatoid arthritis, are major causes of disability and frequently necessitate surgical intervention. Total joint arthroplasty, the surgical replacement of a diseased joint with a prosthetic implant, has become one of the most successful and commonly performed orthopedic procedures. Hip and knee replacements have dramatically

improved mobility and quality of life for millions of patients worldwide.

Prosthetic joint implants are typically composed of metal alloys, ceramics, and high-density polyethylene. Innovations in materials science have focused on enhancing the durability and biocompatibility of implants while reducing wear and the risk of osteolysis. Highly cross-linked polyethylene, oxidized zirconium, and trabecular metal are among the advanced materials now in use.

Minimally invasive surgical techniques and computer-assisted navigation have refined the precision of implant placement, resulting in faster recovery and better functional outcomes. Robotic-assisted joint replacement systems have emerged as a cutting-edge approach, allowing surgeons to plan procedures in three dimensions and execute them with sub-millimeter accuracy. These systems reduce variability, preserve soft tissues, and may extend the longevity of implants.

Shoulder, elbow, and ankle replacements, once considered experimental, are increasingly performed with good results. Revision surgeries for failed implants have also benefited from modular prosthetic systems and improved imaging techniques that facilitate preoperative planning.

Orthopedic Oncology and Limb Salvage Surgery

The management of musculoskeletal tumors has seen significant progress with the development of limb-sparing surgical techniques and endoprosthetic reconstruction. Historically, malignant bone tumors such as osteosarcoma and Ewing sarcoma were treated with amputation. Today, advancements in imaging, chemotherapy, and surgical planning allow for precise tumor resection and reconstruction of the affected limb using custom-made endoprostheses.

Modular tumor prostheses are designed to replace large segments of bone and adjacent joints. These devices are constructed from biocompatible metals such as titanium and cobalt-chrome and are engineered to withstand high mechanical loads. Expandable prostheses have been developed for pediatric patients, allowing for limb lengthening without repeated surgeries.

Custom implants based on three-dimensional modeling and printing are now used to reconstruct anatomically complex defects, including those in the pelvis and scapula. These implants are often combined with biologic grafts and soft tissue flaps to optimize stability and function. Multidisciplinary collaboration between orthopedic oncologists, plastic surgeons, radiologists, and biomedical engineers is essential

for the success of these complex procedures.

Spinal Prosthetics and Vertebral Reconstruction

Spinal disorders, including degenerative disc disease, vertebral fractures, deformities, and tumors, can lead to debilitating pain and neurological impairment. Spinal prosthetics and implants play a central role in the surgical management of these conditions. Intervertebral disc prostheses are designed to replace damaged discs and preserve motion between vertebrae, offering an alternative to spinal fusion in select cases.

Pedicle screws, rods, plates, and cages are used to stabilize the spine, correct deformities, and facilitate fusion. These implants have evolved to include modular systems, expandable cages, and bioactive coatings that promote bone integration. Navigation systems and robotic assistance have improved the accuracy and safety of spinal instrumentation.

Kyphoplasty and vertebroplasty are minimally invasive procedures that use bone cement to stabilize compression fractures in the vertebrae. These techniques provide rapid pain relief and prevent further collapse of the vertebral body. Ongoing research is focused on developing regenerative solutions for disc repair using stem cells, growth factors, and tissue-engineered

scaffolds.

Tendon and Ligament Reconstruction

Tendons and ligaments are critical components of the musculoskeletal system, providing stability and enabling movement. Injuries to these structures, particularly the anterior cruciate ligament in the knee and the rotator cuff in the shoulder, are common in athletes and active individuals. Reconstruction typically involves autografts, allografts, or synthetic grafts.

Autografts, harvested from the patient's own tissues, remain the gold standard due to their high success rate and low risk of immune reaction. Common sources include the patellar tendon, hamstring tendons, and quadriceps tendon. Allografts, obtained from donor tissue, offer the advantage of shorter operative times and reduced morbidity but carry a risk of disease transmission and slower incorporation.

Synthetic ligaments and scaffolds are being developed to overcome the limitations of biological grafts. These materials include polyethylene terephthalate, polyurethane, and collagen-based constructs. While early synthetic ligaments had high failure rates, newer designs with improved mechanical properties and biocompatibility are showing promise in clinical studies.

Biologic augmentation using platelet-rich plasma, mesenchymal stem cells, and growth factors is also being explored to enhance graft healing and integration. These regenerative strategies aim to improve outcomes and reduce recovery times in tendon and ligament repair.

Amputation Surgery and Osseointegration

In cases of severe trauma, infection, or peripheral vascular disease, amputation may be necessary. The approach to amputation surgery has evolved to prioritize the preservation of limb length, optimization of soft tissue coverage, and preparation for prosthetic fitting. Advances in surgical techniques and postoperative rehabilitation have improved functional outcomes and patient satisfaction.

Osseointegration is an innovative technique in which a titanium implant is surgically anchored into the residual bone of an amputated limb, allowing for the direct attachment of a prosthetic limb. This eliminates the need for a traditional socket and improves comfort, mobility, and proprioception. Osseointegration systems have been successfully used in both upper and lower limb amputees and are particularly beneficial for individuals with poor socket tolerance or complex limb anatomy.

The use of sensors and neural interfaces in

osseointegrated prostheses is being explored to provide real-time control and sensory feedback. These systems aim to create a more seamless integration between the user and the prosthetic device, enhancing functional performance and user experience.

Musculoskeletal Transplantation and Allografts

Musculoskeletal allografts are used to replace large segments of bone, cartilage, tendons, and ligaments in patients with trauma, tumors, or degenerative conditions. These grafts are obtained from cadaveric donors, processed to ensure sterility, and stored in tissue banks. Structural allografts, such as femoral heads or tibial segments, are used in joint reconstruction and spinal fusion, while soft tissue allografts are commonly used in ligament and tendon repair.

Fresh osteochondral allografts are particularly valuable in the treatment of cartilage defects, as they provide viable chondrocytes and a natural extracellular matrix. These grafts are used in the knee, shoulder, and ankle to restore joint surface integrity and delay the need for joint replacement.

Composite grafts that include bone, cartilage, and soft tissues are used in complex reconstructions, especially in young or active patients. The integration and remodeling of allografts depend on host factors, graft processing

techniques, and surgical technique. Research into decellularization, cryopreservation, and tissue engineering is aimed at improving the safety, availability, and efficacy of musculoskeletal transplants.

Regenerative Medicine and Tissue Engineering

Regenerative medicine is reshaping the future of orthopedic treatment by focusing on the restoration of damaged tissues through biological means. Stem cell therapy, gene therapy, and tissue-engineered constructs are being investigated for their potential to repair bone, cartilage, and soft tissue defects.

Mesenchymal stem cells have been the subject of extensive research due to their ability to differentiate into osteoblasts, chondrocytes, and tenocytes. These cells can be delivered through injections, scaffolds, or combined with biomaterials to enhance tissue regeneration. Clinical trials have demonstrated the safety and potential benefits of stem cell therapy in conditions such as osteoarthritis, nonunion fractures, and tendon injuries.

Scaffolds made from natural or synthetic polymers provide a three-dimensional framework for cell attachment, proliferation, and differentiation. These scaffolds can be loaded with growth factors such as bone morphogenetic

proteins, transforming growth factor-beta, and vascular endothelial growth factor to stimulate tissue formation.

Bioprinting technology is advancing the fabrication of customized tissues for orthopedic applications. Layer-by-layer deposition of cells and biomaterials can create constructs that mimic the architecture and function of native tissues. Although still in early stages, bioprinting holds promise for the development of patient-specific implants and grafts.

Smart Prosthetics and Robotic Systems

Smart prosthetics equipped with sensors, microprocessors, and actuators are enhancing the functionality and responsiveness of orthopedic devices. These prostheses can adapt to changes in terrain, movement patterns, and user intent, providing a more intuitive and natural experience. Integration with smartphones and wearable devices allows for real-time monitoring, data analysis, and remote adjustment.

Robotic exoskeletons are being used in rehabilitation to assist with movement and muscle activation. These devices provide external support to the limbs and spine, facilitating walking, standing, and exercise in patients with neuromuscular disorders or after surgery. Exoskeletons are also being explored as mobility

aids for long-term use in individuals with spinal cord injuries.

Brain-computer interfaces are an emerging field in which neural signals are decoded to control prosthetic limbs. This technology aims to create seamless communication between the brain and the prosthetic device, restoring voluntary movement and sensory perception. Although still experimental, these systems represent the next frontier in prosthetic integration.

Ethical and Accessibility Considerations

As prosthetic and transplant technologies advance, ethical considerations related to access, cost, and informed consent become increasingly important. High-cost devices and procedures may not be accessible to all patients, particularly in low-resource settings. Equity in healthcare requires policies that support universal access, insurance coverage, and the development of cost-effective solutions.

The use of donor tissues raises concerns about consent, allocation, and traceability. Transparent and ethical tissue banking practices are essential to maintain public trust. In regenerative medicine, the use of stem cells and genetic modification must be carefully regulated to ensure safety and ethical compliance.

Patient education and shared decision-making are crucial in complex orthopedic interventions. Clear communication about risks, benefits, and expectations fosters informed consent and promotes patient-centered care.

Conclusion

The advancement of prosthetics and organ transplantation for orthopedic diseases represents a transformative achievement in modern medicine. These innovations have redefined what is possible in restoring mobility, function, and independence for patients with severe musculoskeletal conditions. From bionic limbs and joint replacements to osseointegration and tissue-engineered grafts, the therapeutic arsenal continues to expand.

Future directions include the integration of regenerative therapies, smart technologies, and personalized care to enhance outcomes and accessibility. Multidisciplinary collaboration, ethical governance, and global equity will be essential to ensure that these life-changing technologies reach all who need them. As research and clinical practice continue to evolve, the vision of fully restoring musculoskeletal function in even the most challenging cases becomes an increasingly attainable reality.

10- ADVANCEMENT OF PROSTHETICS AND ORGAN TRANSPLANTATION FOR OTHER DISEASES

Background

Prosthetics and organ transplantation have long been foundational elements of restorative medicine. While many of the well-known applications relate to diseases of the heart, kidneys, liver, and limbs, the advancement of these technologies for other diseases—those that are rare, systemic, or less commonly discussed—has opened new therapeutic avenues. Diseases involving the immune system, metabolic pathways, reproductive organs, endocrine systems, and complex multisystemic syndromes have begun to benefit from innovations in transplantation and prosthetic integration. These less publicized but equally impactful applications demonstrate the expanding frontiers of biomedical science, combining regenerative medicine, robotics, artificial intelligence, and personalized care. The continuous evolution in this field reflects a broader commitment to addressing a wider array of debilitating and life-threatening conditions through technological and surgical innovation.

Transplantation in Endocrine and Metabolic Disorders

Endocrine diseases, particularly those involving the pancreas and adrenal glands, present unique opportunities for organ transplantation. While pancreatic transplantation has primarily been used to restore insulin production in type 1 diabetes, recent developments have extended its relevance to a broader spectrum of metabolic conditions. Whole-organ pancreas transplantation, islet cell transplantation, and artificial pancreas systems are now being utilized not only to achieve glycemic control but also to mitigate complications of long-standing diabetes, including nephropathy, neuropathy, and cardiovascular disease.

Islet cell transplantation involves the infusion of insulin-producing beta cells into the liver via the portal vein. This procedure offers the potential for insulin independence without the morbidity associated with major surgery. Although immunosuppressive requirements and long-term graft survival remain challenges, protocols involving encapsulated islets and stem cell-derived beta cells are in development to address these limitations.

Transplantation of adrenal tissue is rare but has been explored in cases of adrenal insufficiency unresponsive to conventional hormonal therapy.

More experimental still is the transplantation of parathyroid tissue in patients with hypoparathyroidism following neck surgeries. These transplants are often autologous, meaning the patient's own tissue is reimplanted after being temporarily removed during surgical procedures, and have shown effectiveness in restoring calcium homeostasis.

The parathyroid and pancreatic models illustrate a broader trend: as regenerative medicine advances, it may become increasingly feasible to replace or repair small, hormone-secreting organs that play critical roles in systemic metabolic regulation.

Advances in Reproductive Organ Transplantation

Reproductive medicine has seen some of the most profound ethical and technical advancements in organ transplantation, particularly with uterus and ovary transplantation. Uterine transplantation offers women with congenital absence of the uterus, or those who lost the uterus due to cancer or other pathology, a chance at gestation and childbirth. This procedure is revolutionary for women with Mayer-Rokitansky-Küster-Hauser syndrome and other uterine-factor infertility conditions.

The first successful live birth following uterus transplantation was reported in Sweden in 2014. Since then, numerous successful

deliveries have occurred following both live and deceased donor transplants. These transplants are typically temporary, removed after one or two successful pregnancies, to avoid long-term immunosuppression. The uterus transplant procedure includes complex vascular anastomosis and requires careful immunological and obstetric management throughout gestation.

Ovarian transplantation has been explored in cases of premature ovarian failure and cancer survivors experiencing iatrogenic menopause. Autologous transplantation of cryopreserved ovarian tissue has resulted in restored hormonal function and, in some cases, successful pregnancies. Ongoing research seeks to extend this application to allogeneic ovarian transplants and explore bioengineered ovary models, which may one day eliminate the need for long-term hormone replacement therapy in affected individuals.

Testicular prostheses and penile transplantation represent further areas of advancement. Penile transplantation, although still rare, has been successfully performed in trauma and cancer patients, restoring urinary and sexual function. These transplants carry complex ethical and psychological implications and require long-term multidisciplinary care.

Advancements in Immune

System Reconstruction

Diseases of the immune system, particularly primary immunodeficiencies and hematologic malignancies, are now increasingly managed through hematopoietic stem cell transplantation. Although not an organ in the traditional sense, the bone marrow functions as a dynamic organ responsible for immune cell production. Allogeneic bone marrow or hematopoietic stem cell transplantation is used to reconstitute the immune system in conditions such as severe combined immunodeficiency, leukemia, aplastic anemia, and certain autoimmune diseases.

Recent developments have improved donor matching, reduced graft-versus-host disease, and enhanced engraftment outcomes. Umbilical cord blood transplantation and haploidentical transplantation have expanded the donor pool, making this life-saving treatment available to more patients. Gene-edited autologous transplants are also being investigated to correct underlying genetic defects without the need for lifelong immunosuppression.

Thymus transplantation, though less common, has been used in infants with congenital athymia or DiGeorge syndrome, where the absence of a functional thymus leads to profound T-cell deficiency. Transplanting donor thymic tissue under the skin or into the muscle has shown promise in promoting T-cell maturation and

immune function restoration.

These approaches illustrate the potential for organ and tissue-based interventions to reprogram and rebuild the immune system, a promising concept for autoimmune diseases, immunodeficiencies, and post-transplant tolerance induction.

Skin and Composite Tissue Allotransplantation

Skin is often described as the body's largest organ, and its loss due to burns, trauma, or disease presents not only cosmetic concerns but also severe functional impairments. While skin grafting is a well-established treatment, composite tissue allotransplantation (CTA) has introduced the possibility of full-thickness facial, hand, and scalp transplantation in individuals with severe tissue loss.

Facial transplantation represents one of the most complex and visually transformative procedures in modern medicine. It encompasses skin, subcutaneous tissue, nerves, vessels, and bone, often requiring precise microsurgery and intensive immunologic management. Since the first partial facial transplant in 2005, the procedure has been refined to improve aesthetic and functional outcomes, allowing patients to regain facial expression, mastication, and even speech.

Hand transplantation, another form of CTA, has restored function to patients with traumatic amputations. Functional recovery varies, depending on the level of transplantation, nerve regeneration, and rehabilitation adherence. Advanced prosthetic hands with neural interfaces present an alternative, with their own benefits and limitations, highlighting the ongoing dialogue between biological and mechanical solutions.

The psychosocial impact of composite transplants cannot be overstated. Candidates undergo rigorous psychological screening and post-operative support to adjust to the new body image and lifelong immunosuppression. Despite the challenges, these procedures offer dramatic improvements in quality of life, restoring not only function but also social identity.

Artificial Organ Systems in Multisystem Diseases

Artificial organ systems have become indispensable in the treatment of complex diseases involving multiple organ systems. Devices such as the total artificial heart, wearable dialysis units, and extracorporeal liver support systems provide temporary or long-term function when native organs fail.

Artificial pancreas systems for type 1 diabetes represent an integrated device combining continuous glucose monitoring, insulin delivery,

and automated algorithms to maintain glycemic control. These closed-loop systems are gradually becoming standard of care, reducing the risk of complications and easing the burden of disease management.

For patients with multiple organ failure, devices such as extracorporeal membrane oxygenation (ECMO) and multi-organ support systems act as bridges to recovery or transplantation. Wearable artificial kidneys and liver support devices are being developed to improve mobility and reduce the need for hospitalization.

The growing use of implantable sensors, smart drug delivery systems, and networked health monitoring tools has created a new category of prosthetics—internal digital systems that work in tandem with biological organs to maintain homeostasis.

Regenerative Medicine and Organ Biofabrication

The promise of regenerative medicine lies in its potential to eliminate the need for donor organs altogether. Tissue engineering and organ biofabrication aim to create functional replacements for virtually any organ or tissue type using the patient's own cells and biocompatible scaffolds.

Organ printing technologies are being developed

to produce complex, vascularized structures layer by layer, incorporating multiple cell types and matrix components. While bioprinting fully functional organs like kidneys or lungs remains a distant goal, successful generation of simpler tissues such as skin, cartilage, and vascular grafts is already underway.

Decellularized scaffolds from donor organs offer another pathway. These structures retain the architecture of the original organ and are repopulated with recipient-derived cells to minimize immune rejection. The technique has shown promise in preclinical studies involving hearts, lungs, and livers.

Gene editing technologies such as CRISPR are also contributing to transplant medicine by modifying donor organs to reduce immunogenicity or correct genetic defects in patient-derived cells. These approaches combine the precision of molecular biology with the therapeutic scope of transplantation and prosthetics.

Psychosocial Implications and Ethical Considerations

With every innovation in transplantation and prosthetics comes the responsibility to address ethical, psychological, and social implications. Issues of identity, autonomy, consent, and justice must be central to the deployment of these technologies.

Recipients of facial or reproductive organ transplants, for example, must adapt not only to new functionality but also to a transformed sense of self. Comprehensive preoperative psychological evaluation and long-term support are essential. The concept of enhancement, particularly in neural prosthetics and bionics, raises questions about what constitutes normal or acceptable human function.

Resource allocation remains a major ethical issue. Advanced prosthetics and transplantation procedures are expensive and may not be accessible to all who need them. Policies that promote equity and global accessibility must accompany scientific advancement.

Furthermore, the procurement of donor organs and tissues must be governed by transparent and ethical practices that protect donors and respect cultural values. Research involving stem cells, xenotransplantation, and genetic modification must adhere to rigorous ethical standards to preserve public trust and safety.

Conclusion

The advancement of prosthetics and organ transplantation for diseases outside the traditionally dominant fields reveals the expansive potential of medical innovation. Whether addressing endocrine dysfunction, reproductive health, immune disorders, or

multisystemic syndromes, these technologies are reshaping therapeutic possibilities. As we look forward, the convergence of regenerative medicine, bioengineering, and digital health promises even more personalized, effective, and holistic care.

With this progress comes the imperative to maintain ethical vigilance, ensure equitable access, and prioritize patient-centered outcomes. The success of these therapies is not measured solely by survival or functionality, but by the restoration of dignity, autonomy, and participation in life. As innovation continues to unfold, the future of prosthetics and organ transplantation will not only extend lives but also enrich the human experience.

REFERENCES

1. Abbas K, Mubarak M. Expanding role of antibodies in kidney transplantation. *World J Transplant.* 2025;15(1):99220.
2. Abdelgawad HAH, Aboeldahab H, Belal MM, Bashir MN, Miller HK, Handgretinger R, et al. Comprehensive up-to-date analysis on TCR $\alpha\beta$ /CD19-depleted hematopoietic stem cell transplantation in pediatric hematological malignancies. *Transpl Immunol.* 2025;90:102220.
3. Adekunle RO, Rodrigues M, Durand CM. Evaluating Challenges in Access To Transplantation for Persons with HIV. *Curr HIV/AIDS Rep.* 2025;22(1):26.
4. Aderinto N, Olatunji G, Kokori E, Ogieuhi IJ, Moradeyo A, Woldehana NA, et al. A narrative review on the psychosocial domains of the impact of organ transplantation. *Discov Ment Health.* 2025;5(1):20.
5. Ahmady H, Afrand M, Motaqi M, Meftahi GH. Utilizing Sertoli Cell Transplantation as a Therapeutic Technique for the Management of Neurodegenerative Diseases. *Arch Razi Inst.* 2024;79(4):701-10.
6. Ahmed HS, Dias AF, Pulkurthi SR. Thymus transplantation for DiGeorge Syndrome: a systematic review. *Pediatr Surg Int.* 2025;41(1):82.

7. Akade E, Pournazari S, Abbas Kaydani G, Bahadoram M, Firouzi F. Human Adenoviruses Infection and Kidney Transplantation: Pathogenesis, Diagnosis, and Treatment. *G Ital Nefrol.* 2025;42.(1)
8. Alam A, Hall S. Policy and Oversight of Cardiac Transplantation. *Methodist Debakey Cardiovasc J.* 2025;21(3):83-91.
9. Aldalati AY, Hussein AM, Balbaa E, Hammadeh BM, Idrees M, Aloudat O, et al. Efficacy and Safety of Letemovir for Cytomegalovirus Prophylaxis in Pediatric Hematopoietic Stem Cell Transplantation Recipients: A Systematic Review, Meta-Analysis, and Meta-Regression. *Transpl Infect Dis.* 2025;27(2):e70006.
10. Alegre ML, Atkinson C, Issa F, Valujskikh A, Zhang ZJ. Best practices of heart transplantation in mice. *Am J Transplant.* 2025.
11. Alfares BA, Verhagen MV, Dierckx R, van der Doef HP, de Haas RJ, Bokkers RPH. Diagnosing portal vein stenosis after pediatric liver transplantation: A systematic review. *Transplant Rev (Orlando).* 2025;39(2):100912.
12. Alhowyan AA, Harisa GI. From Molecular Therapies to Lysosomal Transplantation and Targeted Drug Strategies: Present Applications, Limitations, and Future Prospects of Lysosomal Medications. *Biomolecules.* 2025;15.(3)
13. Aljagthmi AA, Abdel-Aziz AK.

Hematopoietic stem cells: Understanding the mechanisms to unleash the therapeutic potential of hematopoietic stem cell transplantation. *Stem Cell Res Ther.* 2025;16(1):60.

14. Alobaidi S. Xenotransplantation of Solid Organs: Revolutionizing Transplantation Through Innovation, Ethics, and Global Solutions. *Med Princ Pract.* 2025:1-18.

15. Alyaydin E, Gotschy A, Parianos D, Nägele MP, Tudorache I, Flammer AJ, et al. Tricuspid regurgitation after heart transplantation: where innovation and intervention are in hibernation. *Heart Fail Rev.* 2025;30(3):619-25.

16. Arora A, Sharma P, Kumar A, Acharya SK, Sarin SK, Duseja A, et al. Indian National Association for the Study of Liver (INASL) Guidance Statements for Determining Futility in Liver Transplantation. *J Clin Exp Hepatol.* 2025;15(5):102539.

17. Astigarraga CC, Mpms K, Iovino L, Milano F. Haploidentical transplantation: An optimal platform for graft manipulation and cellular therapies. *Blood Rev.* 2025:101286.

18. Avramidou E, Psatha K, St John K, Tsoulfas G, Aivaliotis M. Future of non-invasive graft evaluation: A systematic review of proteomics in kidney transplantation. *World J Transplant.* 2025;15(1):96025.

19. Bahrami P, Al Zein M, Eid AH, Sahebkar

A. Liver Transplantation for Non-hepatocellular Carcinoma: The Role of Immune Checkpoint Inhibitors. *J Clin Exp Hepatol.* 2025;15(5):102558.

20. Ball J, Bradley A, Le A, Tisdale JF, Uchida N. Current and future treatments for sickle cell disease: From hematopoietic stem cell transplantation to in vivo gene therapy. *Mol Ther.* 2025;33(5):2172-91.

21. Barandiaran Cornejo JF, Chin LT, Angelis M. From Carrel to Robotics: Renal Transplantation and the Evolution of its Surgical Technique. *Curr Urol Rep.* 2025;26(1):38.

22. Bazarbachi AH, Mapara MY. Cytokines in hematopoietic cell transplantation and related cellular therapies. *Best Pract Res Clin Haematol.* 2024;37(4):101600.

23. Bello I, Ceulemans LJ, Amarelli C. The Path Forward: A Review on Enhanced Recovery After Cardiothoracic Transplantation. *Transpl Int.* 2025;38:14163.

24. Bergier MG, Blanco R, Lillo E, Posatini R, Belziti CA. Cardiac transplantation in muscular dystrophies: A case series. *Curr Probl Cardiol.* 2025;50(4):102997.

25. Bischof L, Ussmann J, Platzbecker U, Jentzsch M, Franke GN. Allogeneic stem cell transplantation for MDS-clinical issues, choosing preparative regimens and outcome. *Leuk Lymphoma.* 2025:1-14.

26. Bondeelle L, Clément S, Bergeron A, Tapparel C. Lung stem cells and respiratory epithelial chimerism in transplantation. *Eur Respir Rev.* 2025;34.(175)
27. Boyer A, Niang A, Darwish R, Kabbali N, Dardim K, Nodimar C, et al. [Peritoneal dialysis in the management of acute kidney injury in children and young adults within French-speaking countries - Partnership between the Société francophone de néphrologie, dialyse et transplantation (SFNDT) and the Saving Young Lives program]. *Nephrol Ther.* 2025;21(2):1-9.
28. Bracken SJ, Poe JC, Sarantopoulos S. What's atypical about human B cells after allogeneic stem cell transplantation? *J Leukoc Biol.* 2025;117.(5)
29. Brännström M, Milenkovic M, Tsakos E. Uterus transplantation: A clinical breakthrough after systematic preclinical research. *Reprod Med Biol.* 2025;24(1):e12636.
30. Brown AE, Roberts J. Intraoperative Hemodynamic Monitoring and Prediction of Early Allograft Dysfunction Following Living Donor Liver Transplantation: A Systematic Review. *Clin Transplant.* 2025;39(2):e70074.
31. Brunaiova L, Cermak S, Koneval L, Roth B, Schneidewind L. [A rapid review: quality of life in adult allogeneic kidney transplantation in the last five years : What can we learn?]. *Urologie.* 2025;64(4):358-68.

32. Byrne MM, Bekki Y, Chávez-Villa M, Hernandez-Alejandro R. Recipient prioritization and graft choice in liver transplantation for colorectal liver metastasis. *Curr Opin Organ Transplant.* 2025;30(3):179-85.
33. Canichella M, de Fabritiis P. Tyrosine Kinase Inhibitor Post-Allogeneic Stem Cell Transplantation in Adult Philadelphia-Positive B-Acute Lymphoblastic Leukemia: State of the Art and Future Directions. *Curr Issues Mol Biol.* 2025;47.(2)
34. Canovai E, Upponi S, Amin I. Intestinal transplantation in Familial Adenomatous Polyposis. *Fam Cancer.* 2025;24(2):40.
35. Cao Z, Gao T, Bajinka O, Zhang Y, Yuan X. Fecal microbiota transplantation-current perspective on human health. *Front Med (Lausanne).* 2025;12:1523870.
36. Carneiro BH, Breda GL, Cognialli RCR, Santos GDD, Vicente VA, Perondi EG, et al. Donor-derived *Cryptococcus gattii* complex infection after liver transplantation. *Rev Soc Bras Med Trop.* 2025;58.
37. Carpenter ML, Cotter EJ, Villarreal-Espinosa JB, Alfonsi S, Gómez-Verdejo F, Gerhold C, et al. Osteochondral Allograft Transplantation With Concomitant Meniscal Allograft Transplantation Improves Clinical Outcomes and Yields High Patient Satisfaction: A

Systematic Review. *Arthroscopy*. 2025.

38. Carrera C, Kervella D, Crespo E, Hafkamp F, Bestard O. Advances on novel biomarkers of alloimmunity in kidney transplantation. *Nephron*. 2025;1-25.

39. Caturano A, Erul E. The impact of incidental hepatocellular carcinoma in liver transplantation: A growing concern. *Clin Res Hepatol Gastroenterol*. 2025;49(3):102550.

40. Chang W, Xu MR, George A, Kingeter M, Henson CP, Mishra K, et al. Hyperkalemia in liver transplantation. *J Clin Anesth*. 2025;103:111822.

41. Chang Y, Qin Y, Zou Y, Zeng H, Li C, Qin M, et al. Plasma-lyte solution versus saline in kidney transplantation: A systematic review and meta-analysis of randomized controlled trials. *PLoS One*. 2025;20(4):e0320082.

42. Charlton M, Rinella ME. Liver Transplantation: Changing Indications and Changing Candidates. *Clin Liver Dis*. 2025;29(2):157-63.

43. Chassot M, Scheen M, Wassmer CH, Compagnon P, Peloso A, Haidar F. Donor after circulatory death in pancreas transplantation: a scoping review of the literature. *Front Transplant*. 2025;4:1517354.

44. Chaturvedi M, Epling BP, Pei L, Sullivan B, Kuehn HS, Hammoud DA, et al. Infection-

Associated Immune Reconstitution Inflammatory Syndrome in Hematopoietic Cell Transplantation. *Transpl Infect Dis*. 2025;27(2):e70000.

45. Chen EY, Dilwali N, Mysore KR, Hassan S, Smith SK, Karnsakul W. Navigating Epstein-Barr Virus (EBV) and Post-Transplant Lymphoproliferative Disorder (PTLD) in Pediatric Liver Transplantation: Current Knowledge and Strategies for Treatment and Surveillance. *Viruses*. 2025;17.(2)

46. Chen K, Yang M, Li G, Wang W. Liver transplantation for NASH-related hepatocellular carcinoma versus non-NASH etiologies of hepatocellular carcinoma: A systematic review and meta-analysis. *PLoS One*. 2025;20(3):e0317730.

47. Chen Y, Shen H, Xu R, Zhu J, Zhu Y, Zou H. Comparative prognosis of liver transplantation versus liver resection in intrahepatic cholangiocarcinoma: a systematic review and meta-analysis. *Chin Clin Oncol*. 2025;14(1):3.

48. Ciesielski W, Frąk W, Gmitrzuk J, Kuczyński P, Klimczak T, Durczyński A, et al. The assessment of the long-term effects of kidney transplantation, including the incidence of malignant tumors, in recipients operated on between 2006 and 2015 - a cohort study and literature review. *Pol Przegl Chir*. 2025;97(2):1-9.

49. Codes L, Zapata R, Mendizabal M,

Junior AMF, Restrepo JC, Schiavon LL, et al. Latin American association for the study of the liver (ALEH) guidance on postoperative care after liver transplantation. *Ann Hepatol.* 2025;30(2):101899.

50. Condon S, Levy C, Martin EF. Recurrent and De Novo Liver Disease After Liver Transplantation. *Clin Liver Dis.* 2025;29(2):313-35.

51. Dac DT, Koshihara H, Cho M, Inaoka PT, Nguyen HTG, Espinoza JL. Sarcopenia and clinical outcomes in lymphoma and multiple myeloma patients receiving hematopoietic cell transplantation: a systematic review and meta-analysis. *Int J Hematol.* 2025.

52. Dai W, Chen X, Zhou H, Liu N, Jin M, Guo Z. Microbiota modulation for infectious complications following allogeneic hematopoietic stem cell transplantation in pediatric hematological malignancies. *Front Pediatr.* 2025;13:1509612.

53. Das R, Greenspan NS. Understanding HLA-DQ in renal transplantation: a mini-review. *Front Immunol.* 2025;16:1525306.

54. Dasari BVM, Line PD, Sapisochin G, Hibi T, Bhangui P, Halazun KJ, et al. Liver transplantation as a treatment for cancer: comprehensive review. *BJS Open.* 2025;9.(3)

55. Davoodi Karsalari P, Asna Ashari K, Rezaei N. NLRP3 inflammasome: significance and

potential therapeutic targets to advance solid organ transplantation. *Expert Opin Ther Targets.* 2025;29(4-5):281-301.

56. de Oliveira Júnior GL, Lins V, Cavalcanti VMB, Tustumi F, Virgílio C, Andraus W. Use of decision algorithms for viscoelastic tests and use of blood products in patients undergoing liver transplantation: A systematic review with meta-analysis. *Transplant Rev (Orlando).* 2025;39(3):100932.

57. Deepti I, Chettri B, Mehra A, Pinheiro AM, Ravi R. Faecal microbiota transplantation for recurrent *Clostridiodes difficile* infection & its global regulatory landscape. *Indian J Med Res.* 2025;161(2):113-9.

58. Deng SS, Zhu YP, Chen ZT, Li W. Application progress of early nutrition intervention in patients with hepatocellular carcinoma after liver transplantation. *World J Gastrointest Surg.* 2025;17(3):100321.

59. Deshpande R, Augustine T. Smart transplants: emerging role of nanotechnology and big data in kidney and islet transplantation, a frontier in precision medicine. *Front Immunol.* 2025;16:1567685.

60. Dewey CW. Poop for thought: Can fecal microbiome transplantation improve cognitive function in aging dogs? *Open Vet J.* 2025;15(2):556-64.

61. Dey R, Das A. Efficacy of mesenchymal stem cell transplantation therapy to mitigate psoriasis: A systematic review and meta-analysis. *Curr Res Transl Med.* 2025;73(2):103504.
62. Dhayanithy G, Radhakrishnan S, Ann Martin C, Caroline Martin J, Hakeem AR, Jothimani D, et al. Understanding immunological insights of liver transplantation: a practice for attaining operational tolerance. *Clin Exp Immunol.* 2025;219.(1)
63. Ding Z, Li Y, Zhou X, Wang C, Zhang Y, He X, et al. The first report of pseudoaneurysm secondary to *Cunninghamella bertholletiae* infection in a Haematopoietic stem cell transplantation recipient: a case report and literature review. *BMC Infect Dis.* 2025;25(1):479.
64. Docherty J. Therapeutic potential of faecal microbiota transplantation for alcohol use disorder, a narrative synthesis. *Prog Neuropsychopharmacol Biol Psychiatry.* 2025;138:111354.
65. Dorent R, Guihaire J, Kerforne T, Abdoul-Anziz N, Goeminne C, Provenchere S, et al. Donation after circulatory death heart transplantation: The French perspective. *Arch Cardiovasc Dis.* 2025.
66. Duarte VE, Urey MA, Adler ED, Merkelz B, Hobeika MJ, Suarez EE, et al. Multi-Organ Transplantation in Adult Congenital Heart

- Disease: Navigating the Unique Challenges of a Distinct Patient Population. *Methodist Debakey Cardiovasc J.* 2025;21(3):72-82.
67. Dutta S, Khan AS, Ukeje CC, Chapman WC, Doyle MB, Scherer M, et al. Anesthetic Considerations for Robotic Liver Transplantation. *J Cardiothorac Vasc Anesth.* 2025;39(6):1571-82.
68. Dzidzishvili L, Allahabadi S, Jackson GR, Gonzalez Ayala S, Sachdev D, Mekhail J, et al. Concomitant Cartilage Procedures With Meniscal Allograft Transplantation Do Not Substantially Alter Failure or Survival Rates Relative to Meniscal Allograft Transplantation Without Cartilage Procedures: A Systematic Review. *Am J Sports Med.* 2025:3635465241305410.
69. Eberlein M, Reed RM, Gharaibeh K, Charya A, Grazioli A, Henderson R, et al. Small recipient chest cavity from fibrotic lung disease in lung transplantation: Physiology matters. *JHLT Open.* 2024;5:100123.
70. El Fakih R, Frutos C, Bonfim C, Weisdorf D, Koh M, Galeano S, et al. Framework for Patient Advocacy in Hematopoietic Cell Transplantation (HCT): An Overview from the Worldwide Network for Blood and Marrow Transplantation. *Hematol Oncol Stem Cell Ther.* 2025;18(1):1-4.
71. Eslami M, Adampour Z, Fadaee Dowlatab, Yaghmayee S, Motallebi Tabaei F, Oksenykh V, et al. A Novel Frontier in Gut-Brain Axis

Research: The Transplantation of Fecal Microbiota in Neurodegenerative Disorders. *Biomedicines*. 2025;13.(4)

72. Fan Z, Han Y, Sun G, Dong Z. Immunosuppressant adherence after heart transplantation: a review on detection, prevention, and intervention strategies in a multidisciplinary. *Front Cardiovasc Med*. 2025;12:1558082.

73. Fathi P, Jafari L, Fathi A, Ahmadi A, Karamlou Y, Behfar M, et al. Hematopoietic Stem Cell Transplantation Outcomes in Diamond-Blackfan Anemia Patients Based on Myeloablative Conditioning Regimen With or Without Total Body Irradiation: A Systematic Review and Meta-Analysis. *EJHaem*. 2025;6(3):e70043.

74. Fernando EM, Balasubramaniam S. Utility of POCUS (Point of Care Ultrasound) in Renal Transplantation. *Indian J Nephrol*. 2025;35(3):329-34.

75. Flores-Treviño S, Bocanegra-Ibarias P, Salas-Treviño D, Ramírez-Elizondo MT, Pérez-Alba E, Camacho-Ortiz A. Microbiota transplantation and administration of live biotherapeutic products for the treatment of dysbiosis-associated diseases. *Expert Opin Biol Ther*. 2025;25(5):1-14.

76. Gadour E. Lesson learnt from 60 years of liver transplantation: Advancements, challenges, and future directions. *World J Transplant*.

2025;15(1):93253.

77. Gang M, Othus M, Walter RB. Significance of Measurable Residual Disease in Patients Undergoing Allogeneic Hematopoietic Cell Transplantation for Acute Myeloid Leukemia. *Cells*. 2025;14.(4)

78. Gannamaneni K, Mian SI. Impact of Sepsis on Corneal Transplantation. *Int Ophthalmol Clin*. 2025;65(2):26-30.

79. Garg A, Goel K, Gour A, Sapra M, Sangwan VS, Tripathi R, et al. Unveiling the Molecular Mechanisms Underlying the Success of Simple Limbal Epithelial Transplantation (SLET). *Cells*. 2025;14.(3)

80. Garry DJ, Garry MG, Nakauchi H, Masaki H, Sachs DH, Weiner JI, et al. Allogeneic, Xenogeneic, and Exogenic Hearts for Transplantation. *Methodist Debaquey Cardiovasc J*. 2025;21(3):92-9.

81. Garuffo L, Leoni A, Gatta R, Bernardi S. The Applications of Machine Learning in the Management of Patients Undergoing Stem Cell Transplantation: Are We Ready? *Cancers (Basel)*. 2025;17.(3)

82. Gatsinga R, Lau RS, Lim BJH, Fong KY, Yeong MZG, Chung AHH, et al. Current Applications and Developments of Natural Language Processing in Kidney Transplantation: A Scoping Review. *Transplant Proc*. 2025;57(4):558-68.

83. Gefen R, Dourado J, Emile SH, Wignakumar A, Rogers P, Aeschbacher P, et al. Fecal microbiota transplantation for patients with ulcerative colitis: a systematic review and meta-analysis of randomized control trials. *Tech Coloproctol.* 2025;29(1):103.
84. Geng A, Yuan S, Yu QC, Zeng YA. The role of endothelial cells in pancreatic islet development, transplantation and culture. *Front Cell Dev Biol.* 2025;13:1558137.
85. Giri G, Doherty D, Azmi S, Khambalia H, Giuffrida G, Moinuddin Z, et al. The impact of pancreas transplantation on diabetic complications: A systematic review. *Transplant Rev (Orlando).* 2025;39(2):100910.
86. González-Bedat MC, Rosa-Diez GJ. Latin American Dialysis and Renal Transplantation Registry: Updates and Progress. *Semin Nephrol.* 2025:151602.
87. Grell R, Paul J, Gupta K, Chawla N, Deshpande R, De Marchi L, et al. Perioperative Point-of-Care Ultrasound Utilization in Abdominal Organ Transplantation. Part I: Preoperative and Intraoperative Care. *Clin Transplant.* 2025;39(4):e70153.
88. Gu C, Sha G, Zeng B, Cao H, Cao Y, Tang D. Therapeutic potential of fecal microbiota transplantation in colorectal cancer based on gut microbiota regulation: from pathogenesis

- to efficacy. *Therap Adv Gastroenterol.* 2025;18:17562848251327167.
89. Guihaire J, Guimbretière G, Lebreton G, Allain G, David CH, Pozzi M, et al. Innovative approaches to organ preservation in heart transplantation: A comprehensive review by the French Society of Thoracic and Cardiovascular Surgery. *Arch Cardiovasc Dis.* 2025.
90. Habal M. Immunosuppression Management in Heart Transplantation. *Methodist Deakey Cardiovasc J.* 2025;21(3):40-50.
91. Han Z, Liu X, Wang H, Qazi IH, Wang L, Du R, et al. Testicular tissue cryopreservation and transplantation as a strategy for feline conservation: a review of research advances. *Front Vet Sci.* 2025;12:1572150.
92. Hansen CM, Bachmann S, Su M, Budde K, Choi M. Calcineurin Inhibitor Associated Nephrotoxicity in Kidney Transplantation- A Transplant Nephrologist's Perspective. *Acta Physiol (Oxf).* 2025;241(5):e70047.
93. Hassanpour P, Sadeghsoltani F, Saghebasl S, Boroumand S, Khanicheragh P, Tafti SHA, et al. Mitochondrial transplantation for cardioprotection and induction of angiogenesis in ischemic heart disease. *Stem Cell Res Ther.* 2025;16(1):54.
94. Hauser G, Benjak Horvat I, Rajilić-Stojanović M, Krznarić-Zrnić I, Kukla M, Aljinović-

Vučić V, et al. Intestinal Microbiota Modulation by Fecal Microbiota Transplantation in Nonalcoholic Fatty Liver Disease. *Biomedicines*. 2025;13.(4)

95. He YJ, Liu PL, Wei T, Liu T, Li YF, Yang J, et al. Artificial intelligence in kidney transplantation: a 30-year bibliometric analysis of research trends, innovations, and future directions. *Ren Fail*. 2025;47(1):2458754.

96. Heger KA, Egger D, Schmidinger G, Skorpik C, Waldstein SM, Pircher N. A historical view of the development of corneal transplantation: from penetrating keratoplasty to selective transplantation of the finest corneal layers. *Wien Med Wochenschr*. 2025;175(7-8):175-85.

97. Hemachandra S, Rathnayake SN, Jayamaha AA, Francis BS, Welmillage D, Kaur DN, et al. Fecal Microbiota Transplantation as an Alternative Method in the Treatment of Obesity. *Cureus*. 2025;17(1):e76858.

98. Hill-Oliva M, Smith NK, Wang R. Regional Nerve Blocks Used in Renal Transplantation and Donor Nephrectomy: A Narrative Review. *Semin Cardiothorac Vasc Anesth*. 2025;10892532251334691.

99. Ho N, Talvard-Balland N, Köhler N, Zeiser R. Immune Escape of Acute Myeloid Leukemia after Transplantation. *Blood Cancer Discov*. 2025;6(3):168-81.

100. Hoffmann DE, Javitt GH, Kelly CR, Keller

JJ, Baunwall SMD, Hvas CL. Fecal microbiota transplantation: a tale of two regulatory pathways. *Gut Microbes*. 2025;17(1):2493901.

101. Hopkinson A, Figueiredo FC. A Narrative Review of Amniotic Membrane Transplantation in Ocular Surface Repair: Unveiling the Immunoregulatory Pathways for Timely Intervention. *Ophthalmol Ther*. 2025.

102. Hou S, Yu J, Li Y, Zhao D, Zhang Z. Advances in Fecal Microbiota Transplantation for Gut Dysbiosis-Related Diseases. *Adv Sci (Weinh)*. 2025;12(13):e2413197.

103. Huang Z, Qian X, Xu Y, Kaindi ST, Pakaya CD, Zhang J. [Hair transplantation in wound healing and scar repair in special areas]. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi*. 2025;39(5):647-54.

104. Ibadov R, Semash K, Akbarov M, Dzhanbekov T, Omonov O, Usmonov A, et al. Exploring the utility of near-infrared spectroscopy in liver transplantation: insights and challenges. *Clin Transplant Res*. 2025.

105. Inoue Y, Cioccio J, Mineishi S, Minagawa K. Evolution of Allogeneic Stem Cell Transplantation: Main Focus on AML. *Cells*. 2025;14.(8)

106. Ishikawa D, Zhang X, Nagahara A. Current Applications and Future Prospects of Fecal Microbiota Transplantation. *Juntendo Med J*. 2025;71(2):68-75.

107. Ito H, Okamura Y, Tomura Y, Oshida J, Fujita M, Kobayashi D. Effect of Antibiotics With Anaerobic Coverage on Graft-Versus-Host Disease in Patients Undergoing Allogeneic Hematopoietic Stem Cell Transplantation: A Systematic Review and Meta-Analysis. *Transpl Infect Dis*. 2025:e70049.
108. Iwata K, Noguchi M, Shintani N. Mitochondrial Transplantation in Animal Models of Psychiatric Disorders: A Novel Approach to Psychiatric Treatment. *Biomolecules*. 2025;15.(2)
109. Jaber F, Abuelazm M, Soliman Y, Madi M, Abusuilik H, Mazen Amin A, et al. Machine perfusion strategies in liver transplantation: A systematic review, pairwise, and network meta-analysis of randomized controlled trials. *Liver Transpl*. 2025;31(5):596-615.
110. Jahns L, Hübner J, Mensger C, Mathies V. A Neutropenic Diet in Haemato-Oncological Patients Receiving High-Dose Therapy and Hematopoietic Stem Cell Transplantation: A Systematic Review. *Nutrients*. 2025;17.(5)
111. Jelencsics K, Oberbauer R. Polygenic risk scores in kidney transplantation. *Curr Opin Organ Transplant*. 2025;30(3):208-14.
112. Jeppesen H. Ocular graft-versus-host disease: Risk factors of ocular graft-versus-host disease after allogeneic haematopoietic stem cell transplantation in Denmark. *Acta Ophthalmol*.

- 2025;103 Suppl 286(Suppl 286):3-19.
113. Jiang K, Pan Y, Pu D, Shi L, Xu X, Bai M, et al. Kidney transplantation in Lupus Nephritis: a comprehensive review of challenges and strategies. *BMC Surg*. 2025;25(1):112.
114. Jiao X, Zhu J, Ding Y, Xiao M, Zhai Z. Effect of herpes zoster vaccine on patients after hematopoietic stem cell transplantation: a systematic review and meta-analysis. *Virol J*. 2025;22(1):54.
115. Jin X, Yan H, Yu Z, Ma J, Zheng X, Chen W, et al. Outcomes of urgent lung transplantation in critically ill patients versus standard lung transplantation: A systematic review and meta-analysis. *Transplant Rev (Orlando)*. 2025;39(3):100933.
116. Jin YF, Wen WJ, Zuo T. [Phages in human health and gut microbiota transplantation therapy]. *Zhonghua Wei Chang Wai Ke Za Zhi*. 2025;28(3):261-5.
117. Jørgensen HS, Vervloet M, Cavalier E, Bacchetta J, de Borst MH, Bover J, et al. The role of nutritional vitamin D in chronic kidney disease-mineral and bone disorder in children and adults with chronic kidney disease, on dialysis, and after kidney transplantation-a European consensus statement. *Nephrol Dial Transplant*. 2025;40(4):797-822.
118. Jothimani D, Marannan NK, Rela M. Acute

liver failure and liver transplantation. *Indian J Gastroenterol*. 2025.

119. Jouve T. [The highlights of kidney transplantation in 2024]. *Nephrol Ther*. 2025;21(S1):18-23.

120. Junna S, Nasser S, Sharma P. Renal Dysfunction and Liver Transplantation. *Clin Liver Dis*. 2025;29(2):273-85.

121. Kamar N, Del Bello A. [Novelties for the management of early complications after kidney transplantation]. *Nephrol Ther*. 2025;21(1):53-6.

122. Kamath S, Bryant RV, Costello SP, Day AS, Forbes B, Haifer C, et al. Translational strategies for oral delivery of faecal microbiota transplantation. *Gut*. 2025.

123. Kasahara M, Sakamoto S. Progress of pediatric liver transplantation: In Japan and beyond. *Chin Med J (Engl)*. 2025;138(8):894-904.

124. Katalinić N, Crnić Marčetić T, Trobonjača Z, Barin-Turica F, Balen S. Development of the Crossmatch Test in Kidney Transplantation Up to the Virtual Level. *J Clin Med*. 2025;14.(4)

125. Katayama A, Patel P, Pianelli A, Wang R, Sakai T. Abdominal Organ Transplantation: Noteworthy Literature in 2024. *Semin Cardiothorac Vasc Anesth*. 2025;29(2):147-58.

126. Kauffman H, Harter S, Yamamoto T. Does Normothermic Machine Perfusion Still

Provide an Advantage for Deceased Donor Kidney Transplantation? A Systematic Review and Preliminary Meta-Analysis. *Artif Organs*. 2025;49(5):749-61.

127. Kenny LA, Armstrong L, Berman M, Brierley J, Crossland D, Dark J, et al. Heart Transplantation and Donation After Circulatory Death in Children. A Review of the Technological, Logistical and Ethical Framework. *Transpl Int*. 2025;38:13801.

128. Khadamy J. Harnessing the Underutilized Potential of Lens Capsule Transplantation in Ophthalmology: A Narrative Review of Current Applications and Future Directions. *Cureus*. 2025;17(4):e82259.

129. Khan MA, Hanna A, Sridhara S, Chaudhari H, Me HM, Attieh RM, et al. Maintenance Immunosuppression in Kidney Transplantation: A Review of the Current Status and Future Directions. *J Clin Med*. 2025;14.(6)

130. Kim SR, Kim SK, Asai A, Nishikawa H. Comparison between Japan and Korea in liver transplantation: Focusing on a higher deceased donation rate in Korea. *Hepatol Res*. 2025.

131. Kiyat P, Palamar M. Strategies for Sustainability and Cost Optimization in Corneal Transplantation: From Surgeons' Perspective. *Turk J Ophthalmol*. 2025;55(1):29-35.

132. Klimešová YM, Netuková M, Baxant

AD, Poláchová M, Studený P. Possibilities of Using Corneal Stromal Lenticules Obtained During ReLEx SMILE Refractive Surgery for Transplantation Purposes. A Review. *Cesk Slov Oftalmol.* 2025;81(1):3-6.

133. Kruiswijk MW, Nguyen Dinh HL, Tange FP, Koning S, van den Hoven P, Peul RC, et al. The safety of indocyanine green in patients with advanced chronic kidney disease or kidney transplantation: a scoping review. *Ann Med Surg (Lond).* 2025;87(3):1351-9.

134. Lafont T, Mukhopadhyay S, Dassanayake SN, Hernández-Fuentes M, Chowdhury P, Kassimatis T. Advances in biomarkers of acute allograft rejection and interstitial fibrosis/tubular atrophy in kidney transplantation; future perspective and challenges in clinical implementation. *Transplant Rev (Orlando).* 2025;39(3):100930.

135. Lai Q, Angelico R, Guglielmo N, Pagano D, Martins PN, Ghinolfi D. Ex-situ normothermic machine perfusion prevents ischemic cholangiopathy after liver transplantation: A meta-regression analysis. *Transplant Rev (Orlando).* 2025;39(2):100915.

136. Lazzari L, Catalano G, Bruno A, Sannipoli D, Lupo-Stanghellini MT, Peccatori J, et al. Post-transplant cyclophosphamide in matched donor transplantation: are we there yet? *Curr Res Transl*

Med. 2025;73(2):103499.

137. Le Bas-Bernardet S, Blancho G. Progress in Porcine Kidney Transplantation to Non-Human Primates. *Transpl Int.* 2025;38:14003.

138. Lee JE, Jung H. Selection of intraoperative fluid for kidney transplantation. *Anesth Pain Med (Seoul).* 2025;20(1):14-22.

139. Lee K, Aviles Vargas A, Bottino R, Wang Y. Islet Transplantation: Microencapsulation, Nanoencapsulation, and Hypoimmune Engineering. *Wiley Interdiscip Rev Nanomed Nanobiotechnol.* 2025;17(3):e70016.

140. Lee N, Ying H. Occurrence rate and risk factors for acute kidney injury after lung transplantation: a systematic review and meta-analysis. *PeerJ.* 2025;13:e18364.

141. Leis L, Tustumi F, Soares-Jr JM, Baracat EC, Carneiro-D'Albuquerque LA, Ejzenberg D, et al. Motivations for uterus transplantation in women with absolute uterine factor infertility: A systematic review of the literature. *Clinics (Sao Paulo).* 2025;80:100646.

142. Lendermon EA, Hage CA. Pulmonary Immunocompromise in Solid Organ Transplantation. *Clin Chest Med.* 2025;46(1):149-58.

143. Lengellé C. Surgical Repair of Deep Melting Ulcers With Freeze-Dried Amniotic

Membrane Transplantation in Dogs and Cats. *Vet Ophthalmol.* 2025.

144. Leung J, Qu L, Ye Q, Zhong Z. The immune duality of osteopontin and its therapeutic implications for kidney transplantation. *Front Immunol.* 2025;16:1520777.

145. Li M, Yu B, Yang H, He H, Gao R. Comparative Efficacy of Non-Pharmacological Interventions on Anxiety, Depression, Sleep Disorder, and Quality of Life in Patients With Liver Transplantation: A Systematic Review and Network Meta-Analysis. *J Clin Nurs.* 2025.

146. Li X, Guan Y, Li C, Cheng H, Bai J, Zhao J, et al. Recent advances in mitochondrial transplantation to treat disease. *Biomater Transl.* 2025;6(1):4-23.

147. Li X, Yin X, Xu J, Geng L. Application of Steatotic Donor Livers in Liver Transplantation. *Korean J Gastroenterol.* 2025;85(2):160-9.

148. Li ZX, Zeng JH, Zhong HL, Peng B. Liver transplantation improves prognosis across all grades of acute-on-chronic liver failure patients: A systematic review and meta-analysis. *World J Gastroenterol.* 2025;31(12):102007.

149. Liao J, Yang Y, Li J, Liu Z, Song S, Zeng Y, et al. Regulatory B cells, the key regulator to induce immune tolerance in organ transplantation. *Front Immunol.* 2025;16:1561171.

150. Liguori C, Magi S, Mandolesi A, Agostini A, Svegliati-Baroni G, Benedetti Cacciaguerra A, et al. Adjuvant treatment with Capecitabine in patients who received orthotopic liver transplantation with incidental diagnosis of intrahepatic cholangiocarcinoma. Implications on DPYD polymorphisms assessment: report of two cases and review of the literature. *Cancer Chemother Pharmacol.* 2025;95(1):40.

151. Lin J, Lubin L, Reardon L, Lluri G, Aboulhosn J, Cruz D, et al. Addressing Complexities in Fontan Combined Heart-Liver Transplantation: A Collaborative Perspective. *Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu.* 2025;28:117-23.

152. Lin J, Selkirk EK, Siqueira I, Beaucage M, Carriere C, Dart A, et al. Access to and Health Outcomes of Pediatric Solid Organ Transplantation for Indigenous Children in 4 Settler-colonial Countries: A Scoping Review. *Transplantation.* 2024;108(12):2324-35.

153. Lin R, Wu J, Liu Q. Epidemiology, clinical outcomes, and treatment patterns of cytomegalovirus infection after allogeneic hematopoietic stem cell transplantation in China: a scoping review and meta-analysis. *Front Microbiol.* 2025;16:1518275.

154. Liu FX, Lin Z, Huang KL. Developing Mouse Models for Ovarian Tissue Transplantation and

Xenotransplantation: A Review. *Med Sci Monit.* 2025;31:e946386.

155. Liu H, Huang L, Liu S, Liu L, Li B, Zheng Z, et al. Evolution of temporomandibular joint reconstruction: from autologous tissue transplantation to alloplastic joint replacement. *Int J Oral Sci.* 2025;17(1):17.

156. Liu S, Wang L, Liu S, Zhao Y. Donor-derived cell-free dna as a diagnostic biomarker for acute rejection in heart transplantation: A systematic review and meta-analysis. *Transplant Rev (Orlando).* 2025;39(2):100916.

157. Liu X, Chen W, Du W, Li P, Wang X. Application of artificial intelligence and machine learning in lung transplantation: a comprehensive review. *Front Digit Health.* 2025;7:1583490.

158. Liu Y, Li X, Chen Y, Yao Q, Zhou J, Wang X, et al. Fecal microbiota transplantation: application scenarios, efficacy prediction, and factors impacting donor-recipient interplay. *Front Microbiol.* 2025;16:1556827.

159. Liu Y, Xia Q. [Current status and prospects of pediatric liver transplantation]. *Zhonghua Wai Ke Za Zhi.* 2025;63(4):300-5.

160. Liu Z, Xu J, Que T, Que S, Valenti L, Zheng S. Molecular Mechanisms of Ischemia/Reperfusion Injury and Graft Dysfunction in Liver Transplantation: Insights from Multi-Omics Studies in Rodent Animal Models. *Int J Biol Sci.*

2025;21(5):2135-54.

161. Ljungman P, Alain S, Chemaly RF, Einsele H, Galaverna F, Hirsch HH, et al. Recommendations from the 10th European Conference on Infections in Leukaemia for the management of cytomegalovirus in patients after allogeneic haematopoietic cell transplantation and other T-cell-engaging therapies. *Lancet Infect Dis.* 2025.

162. Ludwig H, Bernhard S, Ikeda T, Freytes CO, Schreder M, Kawamura K, et al. Allogeneic versus autologous stem cell transplantation after relapsing following first line autologous transplantation for multiple myeloma: A systematic review. *Cancer.* 2025;131(10):e35896.

163. Ma K, Han H, Bao Y, Chen R, Yang Y, Shao W. The Function of B and T Lymphocyte Attenuator and Its Role in Transplantation. *Apmis.* 2025;133(3):e70012.

164. Ma XD, Xu ZL, Huang XJ. Immune Reconstitution after Haploidentical Hematopoietic Stem Cell Transplantation with Different Non-T-Cell Depletion Protocols. *MedComm (2020).* 2025;6(6):e70206.

165. Macris PC, McMillen K. Nutrition issues in adult hematopoietic cell transplantation: A narrative review of latest advances. *Nutr Clin Pract.* 2025;40(3):518-33.

166. Mahmoud S, Sarkar A, AlMahmoud L,

Alladaboina S, Syed LF, Yaghmour M, et al. Solid Organ Transplants Caused by COVID-19 Infection and the Outcome of Transplantation Post-COVID-19: A Systematic Review. *Biomedicines*. 2025;13.(2)

167. Malmut L, Eickmeyer S, Rydberg L, Neal J, Lanphere J, Barker K. The role of rehabilitation across the continuum of liver disease from cirrhosis to transplantation and beyond: A narrative review. *Pm r*. 2025.

168. Mancebo E, Diekmann F, Palou E, Vilches C, Crespo M, Mazuecos A, et al. Spanish guidelines for kidney transplantation in highly sensitized patients with donor-specific anti-HLA antibodies. *Transplant Rev (Orlando)*. 2025;39(3):100919.

169. Marcolin Miranda L, De Lima PEC, Dias Miranda NC, Margraf GZ, Riella J. Donor's therapeutic hypothermia vs. normothermia in kidney transplantation: a meta-analysis of randomized controlled trials. *Front Transplant*. 2025;4:1564460.

170. Maringhini S, Pape L. Kidney Transplantation in Congenital Abnormalities of Kidney and Urinary Tract (CAKUT). *Biomedicines*. 2025;13.(4)

171. Markakis GE, Lai JC, Karakousis ND, Papatheodoridis GV, Psaltopoulou T, Merli M, et al. Sarcopenia As a Predictor of Survival and Complications of Patients With Cirrhosis

After Liver Transplantation: A Systematic Review and Meta-Analysis. *Clin Transplant*. 2025;39(2):e70088.

172. Martins PN, Edil BH, McNally L, Battula NR. Expanding the Use of Ex Situ Organ Machine Perfusion Beyond Transplantation. *Artif Organs*. 2025.

173. Matsuda H. Why is organ transplantation from cardiac death donors necessary in Japan? An important strategy for heart transplantation in severe donor shortage. *J Artif Organs*. 2025.

174. Matsumura S, Kakuta Y, Maegawa-Higa Y, Fukae S, Tanaka R, Nakazawa S, et al. Differences between xenotransplantation and allogeneic kidney transplantation: the current situation and future challenges in Japan. *J Artif Organs*. 2025.

175. Mbaye EHA, Scott EA, Burke JA. From Edmonton to Lantidra and beyond: immunoengineering islet transplantation to cure type 1 diabetes. *Front Transplant*. 2025;4:1514956.

176. McErlean G. Assessment of Survivorship in Allogeneic Hematopoietic Stem Cell Transplantation. *Methods Mol Biol*. 2025;2907:91-125.

177. Meier RPH, Ben Nasr M, Fife BT, Finger EB, Fiorina P, Luo X, et al. Best practices in islet transplantation in mice. *Am J Transplant*. 2025.

178. Mendoza MA, Imlay H. Polyomaviruses After Allogeneic Hematopoietic Stem Cell Transplantation. *Viruses*. 2025;17.(3)
179. Meng G, Feng S, Wang Y. Advances in allogeneic hematopoietic stem cell transplantation for Langerhans cell histiocytosis in children. *Front Immunol*. 2025;16:1345855.
180. Mikulska M, van Bömmel F, Mouliade C, Indolfi G, Kefalakes H, von Lilienfeld-Toal M, et al. Updated recommendations for the management of hepatitis B, C, and E virus infections in patients with haematological malignancies and those undergoing haematopoietic cell transplantation: recommendations from the 9th European Conference on Infections in Leukaemia (ECIL-9). *Lancet Haematol*. 2025;12(5):e389-e99.
181. Mir M, Faiz S, Bommakanti AG, Sheshadri A. Pulmonary Immunocompromise in Stem Cell Transplantation and Cellular Therapy. *Clin Chest Med*. 2025;46(1):129-47.
182. Miyashita S, Alexandrino FB, Vest AR, Fujisaki T, Tang WHW, Tsukamoto Y, et al. Challenges in advanced heart failure care in Japan: Bridging the gap in durable mechanical circulatory support utilization and heart transplantation. *JHLT Open*. 2025;7:100204.
183. Mohammadi I, Farahani S, Karimi A, Jahanian S, Firouzabadi SR, Alinejadfard M, et al. Mortality prediction of heart transplantation

- using machine learning models: a systematic review and meta-analysis. *Front Artif Intell*. 2025;8:1551959.
184. Moriyama S, Kondo M, Awamura R, Hieda M, Fukata M. Role of Cardio-Oncology Rehabilitation in Hematopoietic Stem Cell Transplantation and Chimeric Antigen Receptor T-Cell (CAR-T) Therapy. *Circ Rep*. 2025;7(2):59-65.
185. Moroni G, Calatroni M, Ponticelli C. The Recurrence of Systemic Diseases in Kidney Transplantation. *J Clin Med*. 2025;14.(8)
186. Mou L, Wang TB, Chen Y, Luo Z, Wang X, Pu Z. Single-cell genomics and spatial transcriptomics in islet transplantation for diabetes treatment: advancing towards personalized therapies. *Front Immunol*. 2025;16:1554876.
187. Naegele JR. From Stumbling Blocks to Stepping Stones: Progress in Treating Temporal Lobe Epilepsy With Stem Cell Transplantation. *Epilepsy Curr*. 2025:15357597251318571.
188. Nair R, Li N, Imren S, Kohli P, Lach K, Zhu L, et al. Clinical Outcomes Among Patients With Sickle Cell Disease and Transfusion-Dependent Beta-Thalassemia Treated With Allogeneic Hematopoietic Stem Cell Transplantation: A Systematic Literature Review. *J Blood Med*. 2025;16:135-50.
189. Nasim U, Dorken-Gallastegi A, Dadson P,

Hong Y. Clinical Outcomes of Machine Perfusion and Temperature Control Systems in Heart Transplantation: Where We Stand. *J Clin Med.* 2025;14.(4)

190. Nassereddine N, Roda R, Mhanna R, Damiati LA. Advances in Scaffolds and Additives for Infection Control in Autologous Chondrocyte Transplantation. *Tissue Eng Part B Rev.* 2025.

191. Nikiforow S, Duncan CN. Role of Hematopoietic Cell Transplantation in Pediatric and Adult Hemophagocytic Lymphohistiocytosis-Remaining Unknowns and Challenges. *Hematol Oncol Clin North Am.* 2025.

192. Nikolova AP, Bellumkonda L, Bhardwaj A, Fida N, Holzhauser L, Umapathi P, et al. Practical Guide on the Use of Induction Immunosuppression in Heart Transplantation. *Circ Heart Fail.* 2025:e012382.

193. Niroomand A, Lindstedt S. Current challenges in lung transplantation. *J Intern Med.* 2025;297(4):355-65.

194. Noble J, Anglicheau D, Blancho G, Bertrand D, Couzi L, Durrbach A, et al. [Early conversion to belatacept post-transplantation: state of the art and expert opinion]. *Nephrol Ther.* 2025;21(1):37-47.

195. Nosulya EV, Borovkova NV, Tovmasyan AS, Ponomarev IN, Aleksanyan TA, Polyaeva MY, et al. [Implantation and transplantation materials

in plastic closure of nasal septum perforation (literature review)]. *Vestn Otorinolaringol.* 2025;90(2):55-62.

196. Ohm B, Giannou AD, Harriman D, Oh J, Jungraithmayr W, Zazara DE. Chimerism and immunological tolerance in solid organ transplantation. *Semin Immunopathol.* 2025;47(1):27.

197. Olawade DB, Odetayo A, Marinze S, Egbon E, Chinwah V. Organ transplantation in Africa: Confronting socioeconomic, cultural, and infrastructural hurdles. *Curr Res Transl Med.* 2025;73(3):103516.

198. Ortoleva J, Dalia A, Convissar D, Pisano DV, Bittner E, Berra L. Vasoplegia in Heart, Lung, or Liver Transplantation: A Narrative Review. *J Cardiothorac Vasc Anesth.* 2025;39(4):988-1003.

199. Osburn J, Martinez A, Dains J. Reducing Distress in Caregivers of Patients Undergoing Hematopoietic Stem Cell Transplantation With Remotely Accessible Interventions: An Integrative Review. *J Adv Pract Oncol.* 2025:1-10.

200. Ozturk NB, Uskudar E, Toruner MD, Simsek C, Gurakar A. Drug-induced liver injury: Diagnosis, management and the role of liver transplantation. *Hepatol Forum.* 2025;6(2):72-6.

201. Paccagnella C, Andreola S, Gambaro A, Gambaro G, Caletti C. Immunosuppressive Therapy-Related Cardiovascular Risk Factors in

Renal Transplantation: A Narrative Review. *Cardiorenal Med.* 2025;15(1):209-28.

202. Parmar UPS, Surico PL, Scarabosio A, Barone V, Singh RB, D'Ancona F, et al. Amniotic Membrane Transplantation for Wound Healing, Tissue Regeneration and Immune Modulation. *Stem Cell Rev Rep.* 2025.

203. Pascale MM, Marandola C, Frongillo F, Nure E, Agnes S. Locoregional and Surgical Treatment of Single-Nodule Hepatocellular Carcinoma Recurrence After Liver Transplantation: A Systematic Review and a Meta-Analysis. *Cancers (Basel).* 2025;17.(9)

204. Passos FS, Bregion PB, Oliveira RE, Siemeni T, Tremml RE, Pessoa BM, et al. Cryoanalgesia in Lung Transplantation - A Systematic Review and Meta-analysis. *JHLT Open.* 2025;8:100263.

205. Peras M, Bilić E, Mareković I. Recent Insights into the Pathogenesis, Diagnostics, and Treatment of BK Virus Infections in Children After Hematopoietic Stem Cell Transplantation. *Pathogens.* 2025;14.(3)

206. Pitre T, Gurupatham S, Desai K, Binnie M, Martinu T, Juvet S, et al. Tacrolimus versus cyclosporine immunosuppression in lung transplantation: a systematic review and meta-analysis. *BMJ Open Respir Res.* 2025;12.(1)

207. Popović L, Bulum T. New Onset Diabetes After Organ Transplantation: Risk Factors,

Treatment, and Consequences. *Diagnostics (Basel).* 2025;15.(3)

208. Prabhu NK, Aykut B, Mensah-Mamfo M, Overbey DM, Turek JW. Partial Heart Transplantation: Early Experience With Pediatric Heart Valve Replacements That Grow. *Circulation.* 2025;151(20):1477-90.

209. Qin L, Fan B, Zhou Y, Zheng J, Diao R, Wang F, et al. Targeted gut microbiome therapy: Applications and prospects of probiotics, fecal microbiota transplantation and natural products in the management of type 2 diabetes. *Pharmacol Res.* 2025;213:107625.

210. Quinn S, Catania R, Appadurai V, Wilcox JE, Weinberg RL, Lee DC, et al. Cardiac MRI in Heart Transplantation: Approaches and Clinical Insights. *Radiographics.* 2025;45(2):e240142.

211. R SS, S X, Temitope O, Woo AK, Othman A, Yung-Tsi B, et al. Current Activity Trends and Outcomes in Hematopoietic Cell Transplantation and Cellular Therapy - A report from the CIBMTR. *Transplant Cell Ther.* 2025.

212. Rady ED, Anouti A, Thimphitthaya C, Cotter TG. Liver Transplantation in Alcohol-Associated Liver Disease. *Clin Liver Dis.* 2025;29(2):165-84.

213. Rafie E, Zugman M, Pal SK, Routy B, Elkrief A. What Is the Role of Fecal Microbiota Transplantation in Immunotherapy

Trials? Current Perspectives and Future Directions. *Eur Urol Focus*. 2024;10(6):882-5.

214. Rågård N, Baumwall SMD, Paaske SE, Hansen MM, Høyer KL, Mikkelsen S, et al. Validation methods for encapsulated faecal microbiota transplantation: a scoping review. *Therap Adv Gastroenterol*. 2025;18:17562848251314820.

215. Rahimov D, Yan VZ, Ahmad D, Nasher N, Tatum R, Im M, et al. Characteristics and outcomes of cardiac amyloid disease after heart transplantation: A systematic review and meta-analysis. *Transplant Rev (Orlando)*. 2025;39(2):100908.

216. Rajab TK, Kalfa DM, Mery CM, Emani SM, Reemtsen BL. Indications and Practical Considerations for Partial Heart Transplantation. *Ann Thorac Surg*. 2025.

217. Rajalingam R, Rammohan A, Cherukuru R, Rela M. Minimally Invasive Liver Transplantation: The Recipient Operation. *J Clin Exp Hepatol*. 2025;15(4):102532.

218. Randall J, Gordon A, Boyle C, Curran DW, Hassel H, Russell J, et al. Integrating Social Work Throughout the Hematopoietic Cell Transplantation Trajectory to Improve Patient and Caregiver Outcomes. *Transplant Cell Ther*. 2025.

219. Rao D, Huang D, Peng Z, Xiao D, Xie

C, Zhu S, et al. Triple role of exosomes in lung transplantation. *Front Immunol*. 2025;16:1544960.

220. Rettinger E. Cytokine-Induced Killer Cells: A Unique Platform for Adoptive Cell Immunotherapy after Allogeneic Hematopoietic Stem Cell Transplantation. *Transfus Med Hemother*. 2025;52(1):77-95.

221. Ronan NJ, Helly F, Murray MA. Lung transplantation for interstitial lung disease. *Breathe (Sheff)*. 2025;21(2):240169.

222. Safi K, Pawlicka AJ, Pradhan B, Sobieraj J, Zhytko A, Struga M, et al. Perspectives and Tools in Liver Graft Assessment: A Transformative Era in Liver Transplantation. *Biomedicines*. 2025;13.(2)

223. Saleh RO, Hjazi A, Rab SO, Uthirapathy S, Ganesan S, Shankhyan A, et al. Single-cell RNA Sequencing Contributes to the Treatment of Acute Myeloid Leukaemia With Hematopoietic Stem Cell Transplantation, Chemotherapy, and Immunotherapy. *J Biochem Mol Toxicol*. 2025;39(4):e70218.

224. Salybekov AA, Yerkos A, Sedlmayr M, Wolfien M. Ethics and Algorithms to Navigate AI's Emerging Role in Organ Transplantation. *J Clin Med*. 2025;14.(8)

225. Sanatkar SA, Kinoshita K, Maenaka A, Hara H, Cooper DKC. The Evolution of Immunosuppressive Therapy in Pig-to-

Nonhuman Primate Organ Transplantation. *Transpl Int.* 2024;37:13942.

226. Sanha V, Kasakewitch JPG, Lima DL, Nogueira R, Cavazzola LT, Sreeramoju P, et al. Open Versus Laparoscopic Incisional Hernia Repair Following Liver Transplantation: An Updated Systematic Review and Meta-Analysis. *J Laparoendosc Adv Surg Tech A.* 2025;35(3):210-5.

227. Santana-Gonçalves M, De Santis PB, Malmegrim KCR, Oliveira MC. T-cell Recovery After Autologous Hematopoietic Stem Cell Transplantation in Autoimmune Diseases. *Adv Exp Med Biol.* 2025;1471:301-23.

228. Sassine J, Siegrist EA, Wilson Dib R, Henao-Cordero J, Agudelo Higueta NI. Infection prevention in the immunocompromised traveler due to conditions other than transplantation: a review. *Ther Adv Infect Dis.* 2025;12:20499361251313827.

229. Sequeira LM, Ozturk NB, Sierra L, Gurakar M, Toruner MD, Zheng M, et al. Hepatocellular Carcinoma and the Role of Liver Transplantation: An Update and Review. *J Clin Transl Hepatol.* 2025;13(4):327-38.

230. Shafat T, Ariza-Heredia EJ, Daher M, Chemaly RF. How we diagnose and manage refractory and resistant herpes simplex virus mucocutaneous infection after haematopoietic cell transplantation. *Clin Microbiol Infect.*

2025;31(5):761-72.

231. Shahzad M, Amin MK, Khalid MF, Kasaeian A, Oskouie IM, Yu J, et al. Outcomes with Allogeneic Hematopoietic Stem Cell Transplantation in Therapy Related Myeloid Neoplasms: A Systematic Review and Meta-Analysis. *Clin Lymphoma Myeloma Leuk.* 2025;25(5):e319-e35.

232. Shapiro J, Schiff J, Perl J. Peritoneal dialysis and kidney transplantation: Your questions answered. *Perit Dial Int.* 2025;45(3):142-52.

233. Shin EH, Le Q, Barboza R, Morin A, Singh SM, Castellani CA. Mitochondrial transplantation: Triumphs, challenges, and impacts on nuclear genome remodelling. *Mitochondrion.* 2025;84:102042.

234. Soliman N, Maqsood A, Connor AA. Role of genomics in liver transplantation for cholangiocarcinoma. *Curr Opin Organ Transplant.* 2025;30(2):158-70.

235. Suthantirakumar RL, Gupte GL. Timing and Indications for Liver Transplantation for Children with Chronic Liver Disease. *Children (Basel).* 2025;12.(4)

236. Symeou S, Avramidou E, Papalois V, Tsoulfas G. Global transplantation: Lessons from organ transplantation organizations worldwide. *World J Transplant.* 2025;15(1):99683.

237. Takahashi R, Nakanishi E, Yamakado H, Sawamoto N, Takahashi J. Allogenic transplantation therapy of iPS cell-derived dopamine progenitors for Parkinson's disease - Current status of the Kyoto Trial and future perspectives. *Parkinsonism Relat Disord*. 2025;107833.

238. Tan Z, Zhang X, Feng J, Zhao Y, Hu H, Wu D, et al. Hematopoietic stem cell transplantation and immunosuppressive therapy: implications of clonal haematopoiesis. *Ann Hematol*. 2025;104(3):1877-86.

239. Tanaka Y, Hanada T, Amano T, Takahashi A, Deguchi M, Yamanaka H, et al. Optimizing treatment efficacy and fertility preservation in patients undergoing hematopoietic stem cell transplantation: A narrative review of ovarian shielding with total-body irradiation or treosulfan-based conditioning regimens. *Reprod Med Biol*. 2025;24(1):e12648.

240. Tariq AH, Ali H. Comment on: Evaluation of Cardiac Function in Children Undergoing Liver Transplantation. *Pediatr Cardiol*. 2025.

241. Tejo AM, Rena JA, Romano CM, da Silva AL, Mendes-Correa MC, Mendoza TRT, et al. Coinfection of HHV 6 and HTLV-I Causing Encephalitis After Autologous Hematopoietic Stem Cell Transplantation: A Case Report and a Systematic Review of the Literature. *Transplant*

Proc. 2025;57(3):508-13.

242. Thasleem H, Nadeem MA, Ashraf H, Ishaque G, Saadi M, Ahmed M, et al. Normothermic machine perfusion in liver transplantation: a bibliometric analysis of the top 100 most cited articles. *Ann Med Surg (Lond)*. 2025;87(5):2812-28.

243. Tigano S, Casolaro G, Bianchini A, Bernardi E, Laici C, Ramahi L, et al. Hemodynamic Monitoring During Liver Transplantation for Patients on Perioperative Extracorporeal Membrane Oxygenation (ECMO) Support: A Narrative Review. *Medicina (Kaunas)*. 2025;61.(4)

244. Touhey DC, Beady ND, Tartibi S, Brophy RH, Matava MJ, Smith MV, et al. Return to Sport in Athletes After Osteochondral Allograft Transplantation: A Systematic Review. *Am J Sports Med*. 2025;3635465251315492.

245. Tran TT, Truong TYN, Nguyen HVK, Luu NAT, Than TT, Bui HT, et al. Liver Transplantation for Children With Budd-Chiari Syndrome: A Case Report From Vietnam and Literature Review. *Pediatr Transplant*. 2025;29(2):e70038.

246. Troise D, Allegra C, Cirolla LA, Mercuri S, Infante B, Castellano G, et al. Exploring Potential Complement Modulation Strategies for Ischemia-Reperfusion Injury in Kidney Transplantation. *Antioxidants (Basel)*. 2025;14.(1)

247. Tuokkola J, Anderson CE, Collins S, Pugh

P, Vega MRW, Harmer M, et al. Assessment and management of magnesium and trace element status in children with CKD stages 2-5, on dialysis and post-transplantation: Clinical practice points from the Pediatric Renal Nutrition Taskforce. *Pediatr Nephrol*. 2025.

248. Turra V, Manzi J, Rombach S, Zaragoza S, Ferreira R, Guerra G, et al. Donors With Previous Malignancy: When Is It Safe to Proceed With Organ Transplantation? *Transpl Int*. 2025;38:13716.

249. van de Klundert J, Perez-Galarce F, Olivares M, Pengel L, de Weerd A. The comparative performance of models predicting patient and graft survival after kidney transplantation: A systematic review. *Transplant Rev (Orlando)*. 2025;39(3):100934.

250. van den Berg J, Meloni C, Halter J, Passweg JR, Holbro A. The Changing Role of Allogeneic Stem Cell Transplantation in Adult B-ALL in the Era of CAR T Cell Therapy. *Curr Oncol*. 2025;32.(3)

251. Vassallo GA, Dionisi T, De Vita V, Augello G, Gasbarrini A, Pitocco D, et al. The role of fecal microbiota transplantation in diabetes. *Acta Diabetol*. 2025.

252. Verma I, Seshagiri PB. Current Applications of Human Pluripotent Stem Cells in Neuroscience Research and Cell Transplantation Therapy for Neurological Disorders. *Stem Cell Rev Rep*.

2025;21(4):964-87.

253. Viana P, Castillo-Flores S, Mora MMR, Cabral TDD, Martins PN, Kueht M, 2nd, et al. Normothermic Machine Perfusion vs. Static Cold Storage in Liver Transplantation: A Systematic Review and Meta-Analysis. *Artif Organs*. 2025.

254. Vidal A, Bora C, Jarisch A, Pape J, Weidlinger S, Karrer T, et al. Impact of haematopoietic stem cell transplantation for benign and malignant haematologic and non-haematologic disorders on fertility: a systematic review and meta-analysis. *Bone Marrow Transplant*. 2025;60(5):645-72.

255. Viderman D, Aubakirova M, Nabidollayeva F, Aryngazin A, Romero-Garcia N, Badenes R, et al. The Effect of Transversus Abdominis Plane Block on Pain-Related Outcomes in Kidney Transplantation: A Systematic Review with Meta-Analysis and Trial Sequential Analysis. *J Clin Med*. 2025;14.(6)

256. Vigilante R, Izhar R, Paola RD, De A, Pollastro RM, Capolongo G, et al. Toxoplasma Gondii Replication During Belatacept Treatment in Kidney Transplantation: A Case Report and a Review of the Literature. *Genes (Basel)*. 2025;16.(4)

257. Vionnet J, Miquel R, Abraldes JG, Lozano JJ, Ruiz P, Navasa M, et al. Efficacy and Mechanism Evaluation. The clinical utility and

safety of biomarker-guided immunosuppression withdrawal in liver transplantation: the LIFT prospective RCT. Southampton (UK): National Institute for Health and Care Research

Copyright © 2025 Vionnet et al.; 2025.

258. Ramezani M, Benis DS, Nikakhtar R, Gorjizadeh N, Asadi F, Bagherianlemraski M, et al. Artificial Intelligence in Genomic Medicine: Improving Diagnostic Accuracy and Treatment Outcomes. Kindle. 2025;5(1):1-215.

259. Rahmani E, Farrokhi M, Aghajan A, Gholampour G, Ghoojani E, Shemshadigolafzani R, et al. AI-Driven Strategies for Improving Patient Quality of Life. Kindle. 2025;5(1):1-214.

260. Javadzadeh A, Shafiei D, Amlash RS, Mehrvar R, Sepehrian S, Shafiee A, et al. The Brain-Body Connection: Neuroscience's Role Across Medical Sciences Disciplines. Kindle. 2025;5(1):1-210.

261. Harati K, Mosaddeghi-Heris R, Kiani K, Saligheh Rad M, Morovatshoar R, Kamali M, et al. The AI Revolution: Predicting and Managing the Next Global Health Challenges and Emerging Disease Outbreaks. Kindle. 2025;5(1):1-326.

262. Farrokhi M, Ghalamkarpour N, Nouri S, Babaei M, Rajabloo Y, Sattari M, et al. Innovative Vaccination: A New Era in Cancer Prevention. Kindle. 2025;5(1):1-194.

263. Babaheidarian P, Soltanattar A, Sajadi SK, Rostamian L, Foroutani L, Soleymanpourshamsi T, et al. Robotics in Healthcare. Kindle. 2025;5(1):1-178.

Proof