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Future Research Aspects in Prosthodontics- A Narrative Review

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ABSTRACT: The "future aspects of research" refers to prospective fields or directions that are anticipated to develop or receive attention in the years to come. It includes identifying new opportunities, difficulties, or knowledge gaps that need to be filled. It also covers the themes, emerging technologies, developing trends, and approaches that are expected to have a significant impact on that field's future. It comprises, new technologies, tools, or methods that have the potential to completely transform a field are identified as emerging trends and technologies (e.g., AI, machine learning, digital health tools). Highlighting topics that require more research because they are understudied or absent from the body of existing research. As such very less literature is available on future research aspects in Prosthodontics. This narrative review aimed to mention various aspects of research in prosthodontics.

I. INTRODUCTION

The prospective study topics include:

1. Digital Prosthodontics and CAD/CAM

Integration of digital processes, CAD/CAM technology, and 3D printing in prosthodontics are the main areas of research.Artificial intelligence in treatment planning, intraoral scanning accuracy, material optimisation for 3D printing, and the creation of more effective digital workflows.[1]

2. In prosthodontics, biomaterials

Creating novel biomaterials for prosthetic applications that have improved mechanical characteristics, biocompatibility, and aesthetics is the main area of research.

Studying new materials such as fiber-reinforced composites, bioactive ceramics, and biodegradable scaffolds are potential areas of research.[2]

3. Prosthodontics using implants

Focus of Research on improving the long-term success rate of dental implants, decreasing peri-implantitis, and enhancing osseointegration.Investigating the impact of systemic circumstances on implant success, developing bioactive surfaces, and improving surface modification through nanotechnology. [3]

4. Regenerative Prosthodontics

Regenerating oral tissues by tissue engineering, growth factors, and stem cells. Biomaterials and scaffolds for the regeneration of soft tissues and bone surrounding prosthetic devices. [4]

5. Geriatric Prosthodontics

Xerostomia, edentulism, and decreased masticatory efficiency are among the unique demands of the ageing population that will be the focus of this study.The creation of prosthetic designs tailored to certain age groups, the evaluation of how prosthetic treatment is affected by cognitive decline, and the improvement of treatment options for senior citizens are all potential areas of focus.[5]

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6. Patient-Centered Outcomes in Prosthodontics
To better understand how prosthetic therapies affect patients' choices, levels of satisfaction, and quality of life in creating uniform instruments to assess patient-reported results; investigating the psychological ramifications of dental dentures; and identifying variables influencing patient adherence. [6]

7. Interdisciplinary Prosthodontics
Research Focus on coordinating the treatment of complicated cases amongst the fields of maxillofacial surgery, periodontics, orthodontics, and prosthodontics. Creating guidelines for the multidisciplinary treatment planning and administration of individuals with intricate facial and dental abnormalities is one potential area of focus.[7]

8. Virtual and Augmented Reality in Prosthodontic Education and Practice:
Prosthodontic education, patient education, and treatment planning via virtual reality (VR) and augmented reality (AR), for creating VR/AR training modules for students, increasing patient comprehension of available treatments, and increasing prosthodontic operation accuracy.[8]

9. Occlusion and Temporomandibular Disorders (TMD)
The goal of this research is to examine how temporomandibular disorders are managed, prosthetic therapies, and occlusion interact includes, prosthetic rehabilitation influence on TMD patients, digital occlusal analysis tools development, and longitudinal studies on the effects of various occlusal schemes on TMD.[9]

10. Genomics and Prosthodontics
Examining the genetic influences on tooth loss, dental and craniofacial development, and prosthetic treatment response is the main focus of our research, to determining genetic markers that could indicate a person's propensity to experience dental loss or implant malfunction, customised treatment planning by genetic profiling. [10]

11. Sleep Prosthodontics
Obstructive sleep apnoea (OSA) and other sleep-related diseases are the focus of research, with an emphasis on developing and optimising prosthetic devices. Comparing various mandibular advancement devices (MADs), researching how MADs affect oral health, and incorporating dental sleep medicine into prosthodontic practice are some possible areas of research.[11]

12. Maxillofacial Prosthetics and Oncology
Improvements in maxillofacial prostheses for cancer patients and trauma survivors are the main focus of this research project, to enhancing the comfort and retention of prosthetic devices, investigating 3D printing technology for personalised prostheses, and applying cutting-edge materials for face prosthesis.[12]

13. Prosthodontics for Special Needs Populations
Focus of Research on treating populations with distinct Needs, such as individuals with physical disabilities, systemic diseases, or cognitive impairments, presents distinct obstacles. Creating customised treatment plans, designing accessible prosthetics, and creating cooperative care models with other medical experts. [13]

14. AI and Machine Learning in Prosthodontics
Study aimed to improving prosthetic device customisation, therapy planning, and diagnostic accuracy through the application of artificial intelligence (AI) and machine learning (ML), in creating AI algorithms for automated implant and tooth design, treatment outcome prediction modelling, and machine learning-based real-time diagnostics. [14]

15. Nanotechnology in Prosthodontics
Using nanotechnology to enhance the antibacterial and biomaterial qualities of prosthetic devices is the main area of research for creating antimicrobial nanoparticles; improving prosthetic material durability; and encouraging tissue integration. [15]

II. FUTURE RESEARCH ASPECTS SPECIFIC TO REMOVABLE PROSTHODONTICS

Potential avenues for future research in the field of detachable prosthodontics include material science, digital technology integration, patient-centered care comprehension, and better patient outcomes. In the field of removable prosthodontics, the following specific areas warrant further research:

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A. Advanced Materials for Denture Bases and Teeth

Focus of research for creation of novel materials with improved durability, comfort, and aesthetics for denture bases and teeth. Introduction of fiber-reinforced composites, bioactive materials, and hybrid ceramics to enhance wear characteristics, fracture resistance, and patient satisfaction are potential areas of improvement. In [16]

B. Digital Workflow in Removable Prosthodontics

Aim of research includes utilization of digital technologies for detachable prosthesis manufacture, including CAD/CAM, 3D printing, and intraoral scanning. Possibilities include enhancing digital processes for full and partial dentures and assessing the efficacy, accuracy, and patient outcomes of digital dentures in comparison to traditional techniques. [17]

C. Patient-Centered Outcomes and Quality of Life Studies

Identifying patient-centered outcomes for removable dentures, including comfort, masticatory function, aesthetics, and general satisfaction, is the main area of research. Research on how dentures affect oral health-related quality of life (OHRQoL), the development of novel instruments for measuring patient-reported outcomes, and the enhancement of denture design for customised care are potential areas of focus. [18]

D. Biomechanics and Functional Analysis of Removable Prostheses

Enhancing fit, functionality, and patient comfort through research on the biomechanics of removable dentures. The influence of occlusal systems on comfort and function, denture designs using finite element analysis (FEA), and load distribution optimisation in complete and partial dentures are some potential areas of study. [19]

E. Innovations in Denture Retention Systems

Research mainly aimed for using innovative attachment methods and materials to increase the stability and retention of removable dentures. Research on the long-term efficacy and patient satisfaction of enhanced precision attachments, locator systems, and magnetic attachments are potential areas of investigation. [20]

F. Geriatric Removable Prosthodontics

Examining the unique requirements and difficulties faced by senior citizens who need removable dentures is the main area of research. Recognising the significance of general health and nutrition in prosthetic care; tailoring prosthodontic treatment methods to patients with dementia, cognitive impairment, or reduced dexterity. [21]

G. Removable Partial Denture (RPD) Design and Optimization

Enhancing patient comfort, functionality, and aesthetics through optimised RPD designs is the focus of this study, on the potential research areas to Investigating new attachment mechanisms, enhancing the framework for strength and flexibility, and examining the effects of various clasp designs and materials. [22]

H. Minimally Invasive Techniques in Removable Prosthodontics

Develop less intrusive methods to treat edentulism with removable prostheses is the main focus of research for using adhesive solutions for improved retention, using mini-implants to stabilise dentures, and using minimally invasive methods to treat tissue. [23]

I. Soft Tissue and Bone Preservation Techniques

The focus of this research is on methods for protecting alveolar bone and soft tissue in patients who wear detachable prosthetic devices. Prosthetic design aimed at reducing bone resorption, socket preservation methods investigation, and the impact of denture base materials on soft tissue health are examples of potential areas of research. [24]

J. Biofilm Control and Oral Hygiene for Removable Prostheses

Research focus mainly to creating methods for patients wearing detachable prosthesis to better maintain their oral hygiene and control biofilm growth. Researching better denture cleaning techniques, novel antimicrobial coatings, and patient education regarding dental care. [25]

Enhancing patient care, increasing clinical outcomes, and developing the field of removable prosthodontics are all made possible by these fields.

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III. FUTURE RESEARCH ASPECTS SPECIFIC TO FIXED PROSTHODONTICS

New materials, digital technology, and treatment approaches are anticipated to be the main areas of future research in fixed prosthodontics. Future studies in fixed prosthodontics should focus on the following specific areas:

1. High-Performance Materials for Crowns and Bridges
The goal of the research is to create and test new materials for fixed prostheses that combine strength, aesthetics, and biocompatibility. Long-term clinical research on the wear resistance and performance of these materials; investigation of hybrid ceramics, zirconia-toughened alumina, and advanced polymer composites for crowns and bridges. [26]

2. Digital Workflow Integration in Fixed Prosthodontics
Encouraging the fabrication of fixed prostheses through the use of digital technologies such as CAD/CAM, 3D printing, and intraoral scanning. Enhancing the precision of digital imprints, investigating the medical consequences of entirely digital processes, and formulating novel procedures for effective digital production. [27]

3. Implant-Supported Prostheses and Osseointegration
The goal of the research is to better understand and enhance osseointegration in order to increase the stability and durability of implant-supported fixed prostheses. Creating novel implant surface treatments; examining how loading procedures affect osseointegration; and conducting extended analyses of implant systems' success rates. [28]

4. Biomimetic Approaches in Prosthodontics
Study focus for improving the appearance and functionality of prosthetics by creating materials and designs that closely resemble real teeth. Research on improving bonding methods and biomimetic ceramics and composites that mimic the mechanical characteristics and structure of natural dentin and enamel are potential areas of study. [29]

5. Minimally Invasive Fixed Prosthodontics
The focus of this study is on fixed prosthodontics using minimally invasive methods while maintaining the natural structure of the teeth. Research into adhesive solutions that provide strong bindings with less tooth preparation and the development of ultra-thin veneers, onlays, and inlays are potential areas of study. [30]

6. Long-Term Performance of Fixed Prostheses
Investigating the long-term clinical results and issues connected to different kinds of fixed prosthesis is the main focus of this research. Extensive cohort research contrasting various materials, cementation methods, and prosthetic designs; investigations on the frequency of subsequent caries and prosthetic malfunctions over an extended period of time. [31]

7. Esthetics in Fixed Prosthodontics
The goal of this research is to improve fixed prosthesis aesthetics, especially in the anterior region where aesthetics is crucial. Developing protocols to maximise the aesthetics of implant-supported crowns and bridges; and innovating prosthetic material colour matching, translucency, and texture.[33]

8. Wear and Fatigue Resistance of Prosthetic Materials
Improvement of materials used in fixed prosthodontics to increase wear and fatigue resistance and prolong restoration life is the main focus of research. Composite resins, cements, and wear-resistant ceramics; assessment of these materials' performance in chewing simulations. [33]

9. Adhesive Technologies and Bond Strength
Research focus for rebuilding tooth structure and prosthetic materials using improved adhesive technology to strengthen the bond. Creation of novel adhesive compositions, investigation of the long-term stability of adhesive bonds, and examination of the impact of various surface treatments on bond strength. [34]

10. Patient-Centered Outcomes in Fixed Prosthodontics
Comprehending and enhancing patient-centered results, including overall satisfaction with fixed prostheses, comfort, function, and aesthetics. Possibilities include investigating the psychological effects of fixed prostheses, creating instruments for evaluating patient-reported results, and determining how prosthetic design affects patient happiness. [35]

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IV. FUTURE RESEARCH ASPECTS SPECIFIC TO IMPLANTOLOGY

It is anticipated that future developments in materials, procedures, and technology will lead to advancements in implant success rates, reduced complications, and better patient outcomes. Future study in implantology should focus on the following areas:

a). Next-Generation Implant Materials
Focus of research for creating novel materials to promote long-term stability, lower the risk of peri-implantitis, and improve osseointegration. Investigating antimicrobial materials, nanostructured surfaces, and bioactive coatings to encourage bone formation and guard against infections are possible areas of study. [36]

b). Improved Surface Modifications for Enhanced Osseointegration
The goal of this research is to better understand how advanced surface alterations affect the biological reaction of bone tissue to implants. Bioactive coatings including peptides, growth factors, or hydroxyapatite; innovative surface treatments such chemical etching, laser texturing, and plasma spraying. [37]

c). Peri-Implantitis Prevention and Management
Development of novel approaches for the treatment and prevention of peri-implantitis, a primary factor in implant failure, is the focus of research. Investigating new antimicrobial coatings, non-invasive cleaning methods, and host-modulation treatments; doing extended research on the effectiveness of various interventions. [38]

d). Digital Implantology and Guided Surgery
Using computerised planning, navigation, and guided surgery approaches to improve implant placement accuracy and outcomes is the focus of this study.Examining the effects of robotic-assisted surgery, digital workflows, surgical guides, and real-time navigation on implant success and patient satisfaction. [39]

e). Minimally Invasive and Immediate Loading Protocols
Improving patient comfort and treatment time reduction by immediate loading methods and minimally invasive techniques. Research on the effectiveness and safety of placing implants without flaps, loading implants right away, and using short, narrow implants; clinical studies contrasting minimally invasive and conventional methods. [40]

f). Advancements in Techniques for Bone Augmentation
Enhancing bone augmentation techniques to raise the success rate of implants at compromised sites is the focus of this research. The application of biomaterials, growth factors, and stem cells to bone regeneration; clinical trials evaluating the effectiveness of various grafting materials and methods (e.g., guided bone regeneration, sinus lifts). [41]

g). Intelligent and Living Implants
Creating implants with the ability to actively encourage healing or adapt to changes in their surroundings is the main focus of research. Bioactive implants that release growth factors or antibiotics in response to biological signals; smart implants with sensors integrated in to monitor implant stability or identify early indicators of infection. [42]

h). Impact of Overall Health on Results from Implants
Understanding how systemic health issues (such as diabetes and osteoporosis) affect dental implants' durability and efficacy is the main focus of research. Research on at-risk patient management protocols; longitudinal studies on patients with systemic illnesses to evaluate implant survival rates and complication risks. [43]

i). Studying Quality of Life and Patient-Centered Outcomes
Examining the effects of dental implants on patients' psychosocial outcomes, contentment, and quality of life is the main area of research. Creating patient-reported outcome measures (PROMs) especially for implant users, as well as studying the psychological effects of problems or failures with implants. [44]

j). Repairing Implant Bone Defects via Regenerative Methods
The focus of this research is on regenerative methods for curing implant-related bone abnormalities. Research on the application of platelet-rich plasma (PRP), mesenchymal stem cells (MSCs), and bone morphogenetic proteins (BMPs) for bone regeneration in peri-implant deficiencies are potential areas of endeavour. [45]

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V. PARTICULAR TO MAXILLOFACIAL PROSTHODONTICS, FUTURE RESEARCH ASPECTS

In the field of maxillofacial prosthodontics, future studies will concentrate on enhancing the cosmetic and functional results for individuals with intricate craniofacial imperfections. Improvements in digital technology, surgical methods, materials, and patient-centered care are all mentioned here. These particular topics, along with supporting data, need further investigation in the field of maxillofacial prosthodontics:[46]

1. Superior Digital Technologies for Manufacturing Prostheses
The goal of this research is to improve maxillofacial prosthesis design and manufacture by utilising digital technologies like CAD/CAM, 3D printing, and virtual surgical planning. Research aimed at automating prosthesis design and enhancing the precision and speed of digital workflows via AI and machine learning is one area of potential interest. [47]

2. Maxillofacial prostheses using biomaterials
Creating novel biomaterials with enhanced biocompatibility, durability, and aesthetics for facial prosthesis is the main area of study. Creation of skin-like prosthetic materials with improved texture and colour stability; study on bioactive materials, flexible silicones, and nanocomposite materials that emulate natural tissue qualities. [48]

3. Implant-Retained Maxillofacial Prostheses
Enhancing the results of maxillofacial prosthesis held in place by implants, particularly for individuals with notable anatomical deficiencies, is the main area of research focus.Research on novel attachment mechanisms and loading procedures for implant-retained facial prostheses are potential areas of focus, as are extended investigations on the survival rates and consequences of extraoral implants.

4. Engineering Tissue and Regenerative Medicine
The goal of this research is to better understand how complicated maxillofacial deformities can be repaired by regenerative medicine, which includes tissue engineering and stem cells. creating bioengineered tissues that can work with prostheses; investigating the use of autologous stem cells, growth hormones, and scaffold materials to encourage soft and hard tissue regeneration. [49]

5. In maxillofacial prosthetics, additive manufacturing and 3D printing
Research Focus: Creating more accurate and customised maxillofacial prosthesis through additive manufacturing and 3D printing.
Prospective Domains: Constructing bioprinted facial prostheses that incorporate integrated vascular networks; investigating the application of multi-material 3D printing for the production of prostheses that have realistic colours and textures. [50]

6. Impact on the Psychosocial Domain and Patient-Centered Results
Evaluating the quality of life and psychological effects of maxillofacial prosthesis recipients is the main focus of this research.
Prospective focusses include the creation of patient-reported outcome measures (PROMs) specifically designed for maxillofacial prosthetics and research on how facial prostheses affect mental health, self-esteem, and social reintegration. [51]

7. Genomics and Personalised Medicine
Using personalised medicine techniques to enhance maxillofacial prosthesis treatment results is the main area of research. Precision medicine techniques to customise prosthetic materials and therapies to specific patient profiles; studies on genetic and biomolecular variables impacting wound healing and osseointegration. [52]

8. Prosthetic Rehabilitation Using Advanced Surgical Techniques
The focus of this research is on optimising surgical methods for patients with significant maxillofacial abnormalities undergoing prosthetic rehabilitation. New protocols for reconstruction that maximise the stability and retention of maxillofacial prostheses; flap techniques; and advances in microsurgery.[53]

9. Augmented and Virtual Reality (VR/AR) in the Field of Prosthetic Design
Use VR and AR technology to enhance surgery planning, patient education, and prosthesis design is the main area of research. AR/VR navigation during surgery and patient education regarding prosthetic options and results.[54]

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10. Bioprinting of Facial Soft Tissues
Development of bioprinting methods to regenerate mucosa, skin, and muscles for facial reconstruction is the main area of research.Clinical studies on bioprinted tissue integration with facial prosthetics; research on the application of bioprinting to produce autologous tissue grafts, skin substitutes, and composite tissue flaps. [55]

In order to enhance patient treatment, these research fields focus on incorporating novel materials and technology into the dynamic and ever-evolving field of maxillofacial prosthodontics.

VI. FUTURE RESEARCH ASPECTS IN OBSTRUCTIVE SLEEP APNEA

Improving diagnosis, treating, and comprehending the pathogenesis of obstructive sleep apnoea (OSA) are the main goals of future study. Multidisciplinary approaches, cutting-edge technologies, and personalised and precision medicine are prioritised. Key areas for OSA research in the future include the following:

1. The Use of Precision and Personalised Medicine
Creating individualised treatment programs based on each patient's unique phenotype, genetic profile, and comorbidities is the major area of research.Investigations into distinguishing various OSA characteristics (e.g., positional, REM-related, mild versus severe) and customising therapies appropriately; analyses of genetic and epigenetic markers linked to the intensity of OSA and its reaction to treatment. [56]

2. Progress in Diagnostic Technologies
The goal of this research is to create accessible, non-invasive diagnostic instruments that can effectively diagnose patients outside of conventional sleep laboratories.Artificial intelligence (AI) algorithms for automated sleep study scoring; portable and wearable diagnostic devices; home sleep apnoea testing (HSAT) technologies; smartphone-based sleep monitoring applications. [57]

3. Innovative Medical Equipment and Approaches
The goal of this research is to improve patient outcomes and adherence by investigating novel therapy tools and approaches. Research on novel oral appliances, neurostimulation devices (like hypoglossal nerve stimulators), and alternative positive airway pressure (PAP) therapies (like autoPAP and bilevel PAP); investigations on adaptive servo-ventilation for complex sleep apnoeas. [58]

4. OSA's Epigenetics and Genetics
Emphasis of research to determining biomarkers for risk assessment and therapy by comprehending the genetic and epigenetic roots of OSA. Investigations into the role of epigenetic changes in the onset and progression of OSA; genetic polymorphisms linked to OSA susceptibility, severity, and responsiveness to treatment. [59]

5. Multidisciplinary Methods in the Management of OSA
Examining how several medical specialities may be integrated to treat OSA and its comorbidities is the main area of research. Evaluations of the effects of multidisciplinary care on treatment compliance, patient contentment, and long-term results; investigations of collaborative care models incorporating pulmonologists, dentists, otolaryngologists, cardiologists, and psychologists. [60]

6. Understanding OSA's Impact on Cardiovascular and Metabolic Health
Investigating how OSA affects cardiovascular and metabolic conditions is the main area of research.Investigations into the effects of treating OSA on cardiovascular and metabolic consequences; pathophysiological relationships between OSA and hypertension, atherosclerosis, heart failure, and diabetes.[61]

7. Behaviour and Lifestyle Modifications
The goal of the research is to better understand how behavioural therapies and lifestyle changes can help treat OSA. Studies on optimising lifestyle treatments to improve outcomes by combining them with conventional therapies; studies on reducing the severity of OSA using diet, exercise, weight management, and behavioural therapies. [62]

8. Progress in Pharmaceutical Medicine
The development of novel pharmaceutical medicines to treat OSA or its symptoms is the main area of research. Research on medications that target the arousal threshold, ventilatory control instability, and upper airway

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collapsibility, as well as studies examining the safety and effectiveness of new pharmaceuticals (such as solriamfetol and dronabinol) are examples of potential areas. [63]

9. How OSA Affects Neurodegenerative Diseases and Cognitive Function

Research Interests: Examining how OSA affects cognitive ageing and the likelihood of developing neurodegenerative illnesses like Alzheimer's. Longitudinal studies evaluating cognitive loss in individuals with OSA; investigations into how OSA treatment affects neurocognitive consequences. [64]

10. OSA's Use of Biomarkers and Inflammatory Markers

The main goal of this research is to find and validate biomarkers that may be used to track the course of the condition, forecast how well an OSA treatment will work, and gauge its severity. Investigating the function of inflammatory markers (like C-reactive protein, IL-6) and cardiovascular biomarkers (like NT-proBNP) in OSA; researching the creation of non-invasive biomarkers for early diagnosis. [65]

VII. CONCLUSION

Research is a continuous process, to address the existing challenges and future scope in the field. Prosthodontic researchers also thriving for the future research to benefit the fellow prosthodontist. Everyone should try to undertake some or other research activity for the benefit of their patients.

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