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'Virtuality' in Prosthodontics- A Narrative Review

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ABSTRACT: By providing previously unheard-of precision and speed in treatment planning and prosthesis manufacture, the use of virtual tools and technologies in prosthodontics has completely transformed restorative dentistry practices. This research examines how digital tools like virtual facebows, CAD/CAM systems, intraoral scanners, and predictive analytics can improve diagnostic accuracy and expedite prosthodontic operations. Advanced simulation-based training, digital impressions, and virtual wax-ups have greatly shortened treatment times, decreased mistakes, and enhanced prosthesis fit and functionality. Furthermore, improved decision-making and therapy customization have been made possible by the use of AI-assisted analysis. In prosthodontics, virtuality not only improves clinical results but also lowers patient anxiety and raises patient satisfaction levels. Digital technologies have the potential to further revolutionize prosthodontic care in the future by making it more accurate and patient-centered as they develop.

I. INTRODUCTION

By facilitating more accurate, patient-centered, and efficient care, virtuality is revolutionizing prosthodontics. Important roles consist of: **[1-3]**

1. Treatment Planning and Digital Diagnostics

• Digital Scanning: Traditional impression materials are replaced with intraoral scanners, which produce precise 3D images of the oral cavity. Virtual Treatment Simulations: Practitioners can virtually create prosthetic systems to maximize fit and function using software such as CAD (Computer-Aided create) and CAM (Computer-Aided Manufacturing).

2. Design and Fabrication of Prostheses

• Virtual Wax-Ups: Before manufacturing, practitioners can plan and see restorations or dentures using digital wax-ups. Additive Manufacturing: Using digital blueprints, 3D printing technology creates very precise crowns, bridges, and dentures. Milled Restorations: Accurate prostheses with consistent outcomes are produced by CAM-guided milling machines.

3. Electronic Medical Records

• Integration of Digital Records: By combining radiographs, scans, and photos into a single system, comprehensive digital patient files increase treatment accuracy. AI-Assisted Analysis: AI assesses electronic medical records to help with diagnosis and recommend courses of action.

4. Using Virtual Reality (VR) to Teach Patients

• Immersive Simulations: By using interactive visualizations of their dental health issues and planned restorations, virtual reality applications assist patients in understanding suggested treatments. Anxiety Reduction: Patients who are worried can feel less stressed when they are in virtual settings, which enhances their experience during procedures or treatment planning.

5. Remote Consultations and Teleprosthondontics

• Digital Connectivity: Patients, specialists, and dentists from various regions can consult with each other thanks to virtual platforms. Remote Monitoring: Without the need for regular clinic visits, apps and software monitor the development of detachable prostheses to guarantee a good fit and comfort.

6. Applications for Training and Education

• Simulation-Based Training: Dental professionals and students can safely master intricate prosthesis workflows and practice procedures in virtual environments. Online platforms and virtual reality tools enable professionals from around the world to collaborate on prosthodontic advances through virtual conferences and lectures.

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7. Virtual reality and predictive analytics

• Prognostic Modeling: Based on patient-specific data, physicians can use AI to forecast prosthesis long-term results. Advanced Bite Analysis: By simulating occlusal interactions, virtual articulators aid in the improvement of prosthetic designs.

Digital scanning Its benefits and drawbacks.

Digital Prosthodontic Scanning

Intraoral scanners (IOS) are used in digital scanning to obtain fine-grained three-dimensional images of the oral cavity. This takes the place of conventional techniques that use polyvinyl siloxane (PVS) or alginate and physical impressions. When creating prosthetics like crowns, bridges, dentures, or implants, the digital scan is the starting point.

The Operation of Digital Scanning

1. Preparation: To enhance picture acquisition, the mouth cavity is cleaned and, if necessary, reflecting sprays are used.
2. Scanning: To create a 3D model, a handheld scanner continuously takes pictures of the teeth, gums, and other oral tissues.
3. Procedure: To create an accurate, comprehensive virtual depiction of the oral cavity, sophisticated software stitches the photos together.
4. Use: CAD/CAM systems are utilized to fabricate prostheses, plan treatments, and perform diagnostics using the digital model.

Benefits of Digital Scanning for Medical Professionals

1. Increased Accuracy: Reduces impression errors by capturing subtle anatomical details.
o Research indicates that accuracy is on par with or better than that of conventional techniques.
2. Time Efficiency: Digital files are instantly available, which expedites treatment planning and diagnosis. Removes the requirement for shipping to labs and actual impression materials.
3. CAD/CAM Integration: Digital files simplify workflow by being interoperable with design and milling/printing software.
4. Improved Documentation: Offers thorough records for tracking the course of treatment or future use.

Regarding Patients

1. Comfort: Prevents gag reflex and impression tray discomfort. Less time spent in chairs during scanning sessions.
2. Improved Communication: 3D models aid patients in visualizing their treatment regimens, which increases comprehension and acceptance.
3. Fewer Remakes and Errors: Accurate scanning lowers the possibility of poorly fitting prostheses.

Digital Scanning Drawbacks: Technical Difficulties

1. Learning Curve: To use scanners efficiently, clinicians need to receive training.
2. Technique Sensitivity: Dependent on the operator, improper handling may result in incomplete or distorted data gathering.

Limitations of Software and Hardware

1. Cost: Scanners and related software require a large upfront cost.
2. File Compatibility: Communication problems in the lab may arise from variations in file formats (such as STL, OBJ, and PLY).
3. Technical Problems: Deep subgingival regions, delicate tissues, and reflecting surfaces may be difficult for scanners to scan.

Upkeep and Improvements

1. Technology Lifespan: To stay compatible with evolving software, devices need to be updated or replaced on a regular basis.
2. Data Security: To preserve patient privacy and adhere to legal requirements (such as HIPAA), digital files must be stored securely.

Applications in Clinical Practice

1. Crown and Bridge Work: Guarantees precise margins for the best possible fit.
2. Implant Restorations: Makes custom abutments and guided surgical planning easier.

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3. Detachable prosthodontics: Makes it possible to precisely construct dentures with fewer modifications.
4. Clear aligners and orthodontics: Often used for appliance fabrication and treatment planning.

Prosthodontic Virtual Treatment Simulations

Advanced digital technologies are used in virtual treatment simulations to plan, design, and visualize prosthodontic procedures prior to clinical implementation. Clinicians can simulate different treatment outcomes and construct 3D models of a patient's oral cavity using software that is integrated with CAD/CAM systems. **[4-6]**

Virtual Treatment Simulation Types

1. Virtual Smile Design (VSD): By modifying the size, shape, and alignment of teeth, dentists can digitally create a patient's ideal smile using software such as Digital Smile Design (DSD). Beneficial in cosmetic situations including crowns, veneers, and full-mouth restoration.
2. Virtual Articulators: Digitally replicates jaw movements and occlusion. Aids in assessing how well dentures or restorations fit and work.
3. Implant Planning Simulations: Provides guided surgery by combining digital impressions and CBCT scans. Assures prosthesis compatibility and ideal implant placement.
4.Orthognathic and Orthodontic Simulations: Employed in situations that call for multidisciplinary planning (e.g., maxillofacial surgery, orthodontics, and prosthodontics). Provides precise treatment planning by simulating restorative and surgical outcomes.
5. Denture Fabrication Simulation: Predicts fit and appearance by creating virtual configurations for whole or partial dentures.
6. Pre-Surgical Guides: Showcases both soft and hard tissue alterations, guaranteeing precise performance of operations such as gingival contouring or ridge augmentation.

Benefits for Clinicians of Virtual Treatment Simulations

1. Predictability and Precision: Lowers the margin of error and enables precise diagnostics.
2. Improved Communication: Through the use of common digital platforms, specialists, labs, and clinicians work together more effectively.
3. Simplified Workflow: Cuts down on the amount of time required for fitting and fabrication trial-and-error changes.
4. Comprehensive Treatment Planning: Offers a comprehensive perspective on the course of treatment, particularly for intricate full-mouth rehabilitations.

Regarding Patients

1. Improved Understanding: Enhances acceptance and confidence by enabling patients to see the outcome before therapy starts.
2. Shorter Chair Time: Reduces the need for follow-up appointments for adjustments.
3. Predictable Results: Provides therapies that closely match the expectations of the patient.

Virtual treatment simulations' drawbacks

Technical Difficulties

1. Accuracy Limitations: The dependability of the simulation may be impacted by mistakes in digital scans or CBCT data.
2. Complex Cases: Extensive bone loss or severely damaged teeth may necessitate manual changes that are impossible for digital simulations to foresee.

Cost and Technology

1. High Initial Investment: High-end technology and software are costly.
2. Learning Curve: To utilize virtual tools efficiently, certain training is needed.
3. Ongoing Maintenance: Hardware may need to be replaced from time to time, and software has to be updated frequently.

reliance on digital infrastructure

1. File Compatibility Problems: It can be difficult for several software platforms to work together.
2. Risk of Data Loss or Breach: Strict data protection laws (such as HIPAA and GDPR) must be followed by digital files.

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Use of Virtual Treatment Simulations in Clinical Settings

1. Single and Multi-Unit Restorations: Guarantees accurate occlusal harmony and margin adaption.
2. Implant-Supported Prostheses: Makes it possible to precisely plan the prosthetic shapes and implant angulation.
3. Multidisciplinary Care: Encourages cooperation in situations including oral surgery, periodontics, and orthodontics.

Upcoming Patterns

1. Artificial Intelligence (AI): Using AI will improve treatment forecasts and offer evidence-based suggestions.
2. Augmented Reality (AR): Using virtual simulations, real-time AR overlays could allow for intraoperative guidance.

Wax-Up Virtually in Prosthodontics

A computerized depiction of the intended prosthetic or restorative result made with sophisticated CAD (Computer-Aided Design) software is called a virtual wax-up. It mimics the final prosthesis's construction, functionality, and look. With their increased precision and smooth integration into digital workflows, virtual wax-ups take the role of traditional manual wax-ups. **[5,7,8]**

Virtual Wax-Up Workflow Steps:

1. Data collection: The 3D architecture of the patient's oral cavity is captured via intraoral scanning, also known as CBCT imaging. CAD software is used to import these scans.
2. Design Process: To align the wax-up with the treatment plan, the dentist or technician virtually modifies the tooth's shape, alignment, and occlusion. Changes can be performed immediately in response to patient input or clinical requirements.
3. Simulation: The occlusion, aesthetics, and functional balance of the virtual wax-up are examined.
4. Fabrication Using 3D printing or milling, the completed design can be utilized to create surgical guides, temporary restorations, or the finished prosthesis.

Utilizing Virtual Wax-Up in Applications

1. Visually appealing repairs: Precise planning of tooth shape and color is advantageous for veneers, crowns, and bridges.
2. Implant Planning: Establishes the optimal prosthetic shapes and placement for restorations supported by implants.
3. Full-Mouth Rehabilitation: Pre-plans occlusion and functional harmony to facilitate challenging instances.
4. Cases in Orthodontics: Models the ultimate tooth alignment for post-orthodontic restorations or clear aligners.

Benefits of Virtual Wax-Up for Medical Professionals

1. Improved Control and Accuracy: Digital workflows produce predictable results and reduce human error.
2. Time Efficiency: Several manual revisions are not necessary when design changes are made quickly.
3. Integration with CAD/CAM: Easily switches to processes for 3D printing or milling to produce mock-ups or prostheses.
4. Better Communication: Offers a clear visual aid for talking with patients or experts about treatment strategies.

Regarding Patients

1. Results Visualization: This helps patients better grasp and trust the treatment plan by giving them a realistic sneak peek at the end result.
2. Comfort: Lessens patient discomfort by doing away with the requirement for physical imprints.
3. Trial Restorations: Patients can "test" the outcomes by having temporary restorations made straight from the virtual design.

Virtual Wax-Up's drawbacks include its technical restrictions.

1. Learning Curve To become proficient using CAD software for virtual wax-ups, dentists and technicians must receive training.
2. Accuracy Issues: Incomplete data collection or scanning mistakes could compromise the design's accuracy.

Dependency on Technology

1. Cost: Purchasing digital hardware and software can require a sizable upfront expenditure.
2. File Compatibility Problems: There may be difficulties with interoperability among various software systems.
3. Updating and maintaining software: Costs may rise as a result of frequent updates and possible device obsolescence.

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Clinical Restrictions

1. Complex Cases: Manual interventions may be necessary in cases of deep subgingival areas, extensive wear, or missing landmarks.
2. Absence of Tactile input Some technicians prefer tactile input, which virtual designs do not offer like traditional wax-ups do.

Additive Production in Dental Implants

Direct layer-by-layer creation of items from digital files is known as additive manufacturing (AM), or 3D printing. AM is transforming the manufacturing of dental restorations, surgical guides, and prostheses in the field of prosthodontics. It provides improved accuracy, effectiveness, and personalization. **[9-11]**

The Prosthodontic Additive Manufacturing Process

1. Digital Design: CAD software is used to produce a 3D model of the prosthesis, which is frequently based on digital scans of the patient's oral cavity.
2. Material Preparation: The right substance, such as metal powders, polymers, or resins, is chosen.
3. Printing: One of various AM methods (such as stereolithography or selective laser sintering) is used to print the object layer by layer.
4. Post-Processing: The prosthesis is prepared for clinical usage by procedures including curing, polishing, or sintering.

Materials for Prosthodontic Additive Manufacturing

1. Resins and polymers: Photopolymer resins for SLA (Stereolithography) printers are one example of how they are used for interim crowns, bridges, and denture bases.
2. Metal Alloys: Cobalt-chromium and titanium alloys for implant components and frameworks.

Direct Metal Laser Sintering (DMLS) and Selective Laser Sintering (SLS) both use it.

3. Ceramics: Materials based on zirconia for restorations with great strength.

o Limited use since direct ceramic printing is difficult.

4. Hybrid Materials: Glass-filled polymers and composite resins for aesthetically pleasing repairs.
5. Biomaterials: Biocompatible materials for scaffolds and directed tissue regeneration, such as bioresorbable polymers.

Types of Prosthodontic Additive Manufacturing Technologies

1. Stereolithography (SLA): Cures photopolymer resin layer by layer using UV light. Uses: temporary crowns, surgical guides, and denture bases.
2. Selective Laser Sintering (SLS): Uses a laser to fuse powdered material. Applications include partial dentures and metal frames.
3. Layer by layer, thermoplastic material is deposited using fused deposition modeling (FDM). Uses:Non-load-bearing dental models and prototypes.

The fourth method is Digital Light Processing (DLP), which is comparable to SLA but cures using a digital light projector.

Uses: incredibly intricate dental models and manuals.

Clinical Benefits of Additive Manufacturing Advantages

1. Customization: Accurately adjusts prosthesis to meet the demands of each patient.
2. Accuracy: AM attains micron-level precision, which is essential for surgical guiding and restorations.
3. Complex Geometries: Makes it possible to create complex structures that are challenging to create using conventional techniques, such as lattice frameworks.
4. Efficiency: Shortens the time between design and delivery, especially for restorations done the same day.

Benefits of Cost

1. Material Efficiency: Reduces waste by utilizing only what is required.
2. Lower Labor Costs: Reduces the need for manual intervention by automating fabrication.

The drawbacks of additive manufacturing include its technical difficulties.

1. Material Restrictions: There aren't many appropriate biocompatible materials available, especially ceramics.
2. Surface Finish: Post-processing is necessary to produce a smooth surface for both aesthetically pleasing and functional restorations.
3. Layering Artifacts: Printed goods' visible layers may have an impact on fit and appearance.

Expense and Availability

1. High Initial Investment: The cost of 3D printers and related supplies might be high.
2. Maintenance and Training: Needs competent operators and routine calibration.

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Issues with Regulation and Validation
1. Standardization: Dental AM materials and procedures do not have global standards.
2. Biocompatibility: To ensure durability and safety, certain materials may require thorough testing.

Applications in Prosthodontics
1. **Fixed Prostheses:** Crowns, bridges, and implant frameworks.
2. **Removable Prostheses:** Denture bases and partial frameworks.
3. **Surgical Guides:** Guides for implant placement.
4. **Orthodontics:** Aligners and brackets.
5. **Educational Models:** Dental training and patient education.

Prosthodontic Milled Restorations
Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) technology is used in the subtractive manufacturing process to construct milled restorations, which require carving a restoration from a solid block of material. Crowns, bridges, inlays, onlays, veneers, and implant-supported prostheses are all frequently made using this method. **[12- 14]**

Milled Restoration Types
1. Crowns and Bridges: Single-unit crowns and multi-unit bridges made of zirconia, lithium disilicate, or hybrid ceramics are examples of materials that are milled.
2. Onlays and Inlays : Conservative cavity preparation using precision-fit restorations.
3. Veneers: incredibly thin and beautiful repairs for front teeth.
4. Implant-Supported Prostheses : Full-arch restorations, frameworks, and custom abutments.
5. Temporary Restorations: Temporary prosthesis made from PMMA (polymethyl methacrylate) blocks.

Materials for Restorations That Are Milled
1. Zirconia: Long-term durability, biocompatibility, and high strength. Appropriate for bridges and posterior crowns.
2. Lithium Disilicate: Excellent translucency and appearance; o Perfect for veneers and anterior crowns.
3. Hybrid Ceramics: A blend of resin and ceramic that improves flexibility and machining ease.
4. Polymethyl Methacrylate, or PMMA, is used for mock-ups and interim repairs.
5. Metal Alloys : Cobalt-chromium or titanium for bespoke abutments and implant frameworks.

Benefits of Milled Restorations for Medical Professionals
1. Fit and Precision: Milled restorations have minor adaptability and excellent precision.
2. Predictable Workflow: Digital design minimizes errors and guarantees consistency.
3. Shorter Chair Time: Same-day restorations are made possible by in-house milling technology.
4. Material Versatility: Numerous clinical scenarios are supported by a broad range of materials.

Regarding Patients
1. Aesthetic Appeal: Natural color and translucency are provided by materials such as lithium disilicate.
2. Durability: Long-term fixes for high-stress locations are provided by zirconia and other robust materials.
3. Minimally Invasive: Designs are tailored to reduce teeth as little as possible.
4. Comfort : Post-placement tweaks are less necessary with well-adapted repairs.

The drawbacks of milled restorations for clinicians are as follows:
1. Initial Cost: A significant outlay of funds for milling machines and CAD/CAM systems.
2. Learning Curve: To become proficient in using hardware and software, one must receive instruction.
3. Tool Wear Over time, milling burs deteriorate, decreasing accuracy and raising expenses.
4. Material Waste o When compared to additive procedures, subtractive manufacturing produces more waste.

Regarding Patients
1. Restricted Shades of Beauty: Not every single tooth shade will match precisely with pre-shaded blocks.
2. Fracture Risk: Veneers and other thin restorations that are milled may become fragile in the process.

Clinical Applications
1.Anterior Aesthetic Cases- Lithium disilicate veneers and crowns.
2.Posterior Functional Cases -Zirconia crowns and bridges for durability.

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3.Implant-Supported Restorations- Titanium and zirconia custom abutments.
4.Full-Mouth Rehabilitations-Large-scale restorations with consistent quality.

Integration of Digital Records and AI-Powered Analysis in Prosthodontics
Integrating all patient data into a single digital platform, including medical history, diagnostic imaging, intraoral scans, treatment regimens, and laboratory procedures, is known as digital record integration. In order to help diagnosis, treatment planning, and patient monitoring, this integrated data is processed and analyzed using machine learning algorithms in conjunction with AI-assisted analysis. **[11,15-17]**

Elements of Integrating Digital Records
1. Acquisition of Data
o Intraoral scanners, or digital impressions.
o Imaging with radiography (CBCT, panoramic X-rays).
o Patient records, including photos and medical histories.
2. Storage in One Place
o Cloud-based platforms safely store and arrange patient data.
3. Compatibility
o Integration with practice management software, lab software, and CAD/CAM systems.
4. Real-Time Updates: The most recent records are accessible to all parties involved, including patients, technicians, and clinicians.
5. AI-Assisted Analysis
Machine learning models examine datasets to find trends in diagnosis, forecast the course of treatment, and track outcomes after treatment.

Prosthodontic Applications of AI and Digital Record Integration
1. Planning for Diagnosis and Treatment - To identify dental abnormalities or develop treatment plans, AI examines radiographs, intraoral scans, and occlusion patterns.
2. Predictive Analytics AI forecasts the results of treatment modalities or prosthetic designs.
3. Digital Smile Design- Creates aesthetically pleasing results by fusing prosthetic designs with patient facial scans.
4. Real-Time Monitoring- Keeps track of patient compliance with care instructions, prosthesis wear, and performance.
5. Education and Communication -Enables patients to picture their treatment regimens and anticipated results.

Benefits of Clinical Efficiency with Digital Record Integration
1. Simplified Processes
o Centralized records cut down on errors and duplication.
2. Quicker Diagnosis AI speeds up the analysis of intricate datasets, including CBCT scans.
3. Better Cooperation - Multidisciplinary teams are better able to coordinate when records are shared easily.

Precision and Forecasting
1. Increased Precision AI is highly accurate in measuring therapy success and identifying subtle diseases.
2. Tailored Treatment Plans - Personalized strategies founded on thorough data analysis.

Engagement of Patients
1. Improved Communication: Trust and understanding are increased when treatment plans are visualized.
2. Remote Monitoring -By employing digital instruments for patient monitoring, follow-up visits can be decreased.

The drawbacks of integrating digital records include technical difficulties.
1. Interoperability Problems-may be constrained by compatibility between several software systems.
2. Data Security Risks -There is a higher chance of breaches when private patient data is stored on digital platforms.
The price
1. High Initial Investment -Training, software, and hardware expenses can be unaffordable.
2. Maintenance - Constant investment is needed for regular upgrades and troubleshooting.

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Limitations of AI

1. Accuracy Dependence: AI algorithms rely on training datasets that are diverse and of high quality, which may create biases.
2. Regulatory Obstacles: Standardized rules for the application of AI in dentistry are lacking.

Analysis Supported by AI in Prosthodontics

AI has revolutionized the use of data from digital records: Essential Roles

1. Diagnostic Support

More accurately detects cavities, fractures, or problems with bone density from radiographs than conventional techniques.

2. Prosthetic Design Optimization- Makes recommendations for the best implant, crown, and bridge designs based on biomechanical information.
3. Occlusal Analysis-Improves functional results by simulating and assessing occlusal motions.
4. Outcome Prediction-Forecasts prosthesis treatment longevity and possible consequences.

Benefits of Analysis Assisted by AI

1. Increased Accuracy

o AI produces consistent outcomes, which lowers human error.

2. Time Efficiency- Automates laborious procedures such as interpreting radiographs.
3. Data insights- Finds patterns and trends in patient datasets to help with better decision-making.

AI-Assisted Analysis Drawbacks

1. Reliance on Data Quality Inaccurate suggestions may result from biased or insufficient datasets.
2. Ethical and Legal Issues- Privacy issues and unclear legal frameworks around the application of AI in healthcare.
3. Technical Restrictions: To ensure accuracy, it needs to be updated and improved on a regular basis.

Dental Immersion Simulation

Utilizing cutting-edge technology like as Virtual Reality (VR), Augmented Reality (AR), or Mixed Reality (MR), immersive simulation creates incredibly realistic and interactive learning, treatment planning, and patient care settings. It mimics real-world situations by combining visual, aural, and occasionally touch feedback. Immersion simulations are used in prosthodontics and dentistry for patient education, procedure planning, and dental professional training. **[18-22]**

Immersion Simulation Components

1. Virtual Reality (VR): Head-mounted displays (such as the Oculus or HTC Vive) that create completely immersive settings.
2. Augmented Reality (AR) : Uses gadgets like smartphones or AR glasses to superimpose digital features on the physical world.
3. Haptic Feedback :Tools, materials, and operations are simulated through tactile sensations on devices.
4. Dental-specific simulation software for treatment planning and procedural training.

Uses in Prosthodontics and Dentistry

1. Education and Training-Models dental operations (e.g., implant placement, crown preparation). Provides risk-free, secure settings for skill practice.
2. Treatment Planning- Provides accurate planning by visualizing intricate prosthodontic cases in three dimensions.
3. Patient Education-Gives patients access to digital depictions of the results of their treatments.
4. fear Reduction: By immersing patients in serene virtual worlds, virtual reality helps patients forget about their dental fear.

Immersion Simulation's Benefits for Education

1. Risk-Free Training: Students can frequently practice methods without running the risk of getting hurt.
2. Skill Development o Through realistic procedural simulations, accuracy and confidence are increased.
3. Instant Feedback: Simulation software provides direction and performance indicators.

Clinical Advantages

1. Improved Visualization:3D models aid in more precise treatment planning by physicians.
2. Patient Engagement: Visual aids enhance trust and communication, which boosts adherence.

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For the Management of Anxiety
1. Distraction Therapy: VR settings that mimic serene forests or beaches help people feel less stressed.
2. Non-pharmacological Method- Lessens dependency on anesthetic or sedatives.
3. Kid-Friendly Apps - Maintains kids' attention and composure throughout processes.

Cons of Immersive Simulation: Technical Difficulties
1. Expensive upfront expenses - Costly equipment includes haptic devices and virtual reality headsets.
2. Learning Curve to effectively use the technology, both students and therapists need training.
3. Technical Restrictions - Learning might be impacted by limited resolution or latency.
Patient-Specific Problems
1. Not Suitable for Everyone: Patients who suffer from claustrophobia or motion sickness may not benefit from VR.
2. Device Maintenance- Regular maintenance and updates are required due to frequent use in clinical settings.

Insufficient Proof
1. Long-Term Efficacy -Additional study is required to confirm immersive technology' efficacy in medical settings.

How Virtual Reality Lowers Dental Anxiety: Anxiety Reduction Mechanisms
1. Distraction: Virtual reality (VR) allows patients to focus on soothing virtual settings, such as gardens or beaches, instead of dental treatments.
2. Controlled Environmen-In virtual reality settings where they have control over their surroundings, patients feel safer.
3. Less Sensory Overload- Upsetting noises, such as dental drills, are muffled by immersive graphics and noise-cancelling headphones.
4. Gradual Exposure Therapy- By allowing patients to virtually acquaint themselves with dental environments, VR gradually lessens anxiety.

VR's Benefits for Reducing Anxiety
1. Non-Invasive o Has no adverse effects in contrast to pharmaceutical treatments.
2. Patient-Friendly-Customized virtual reality settings accommodate each person's requirements and preferences.
3. Long-Term Cost-Effective - Lessens the demand for sedatives or prolonged sitting because of nervous patients.

VR's Drawbacks for Reducing Anxiety
1. Initial Expenses
For smaller dental offices, VR equipment might be costly.
2. Limited Suitability - VR settings may cause discomfort or vertigo in certain patients.
3. Equipment Dependency - Top-notch gear and software are essential for success.

Applications and Utility of Tele-Prosthodontics
The use of communications technology in prosthodontics to enable remote consultation, diagnosis, treatment planning, and follow-up care is known as tele-prosthodontics. The necessity for accessible care in underserved areas and the growing digitization of healthcare have made this subcategory of tele-dentistry more significant. **[23-26]**
Tele-Prosthodontics' Usefulness
Particularly helpful situations for tele-prosthodontics include the following:
1. Expertise Access -Makes specialized prosthodontic care available to patients in underserved or rural places.
2. Continuity of Care: This eliminates the need for in-person visits by facilitating follow-up consultations and minor adjustments after the surgery.
3. Time and Cost Efficiency-Cuts down on clinic operating expenses and patient travel time.
4. Pandemic Resilience - Continues to provide care under circumstances such as COVID-19, when in-person visits are scarce.
5. Collaborative Treatment -Improves communication in complex cases between prosthodontic specialists and regular dentists.

Uses for Tele-Prosthodontics
1. Remote Diagnosis and Consultation
For initial assessment, patients can submit radiographs, intraoral scans, or photos to professionals. AI-assisted technologies can examine the data submitted for increased diagnostic precision.

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2. Treatment Planning: Digital impressions and 3D models may be analyzed cooperatively, and specialists can consult with patients or referring dentists via virtual meetings to discuss treatment alternatives.
3. Prosthesis Fabrication and Adjustment- Digital imprints can be sent to labs by dentists in remote locations to fabricate bridges, dentures, or crowns; Virtual consultations help dentists fit and modify prostheses.
4. Post-Treatment Follow-Up -By using video conversations, patients can report discomfort, fit problems, or maintenance requirements, reducing the need for needless clinic visits.
5. Education and Training: Dentists can take part in webinars or remote training sessions on cutting-edge prosthodontic techniques, and patients can get education about prosthodontic treatments and care via telecommunication platforms.
6. Cooperation with Labs: Digital workflows allow dental labs and clinics to communicate easily and provide real-time information on the manufacturing of prosthetics.
7. Virtual Prosthetic Trials: Patients can see how proposed prosthetic restorations will look using virtual reality or augmented reality.

Tele-Prosthodontic Benefits
1. Accessibility: Provides remote and underserved areas with access to skilled prosthodontic care.
2. Convenience: It eliminates the need for in-person meetings and travel.
3. Improved Cooperation: This enhances collaboration amongst laboratories, specialists, and general dentists.
4. Time Efficiency: By using computerized tools for diagnosis and planning, treatment procedures are accelerated.
5. Cost-Effectiveness: It lowers clinic overhead and patient travel expenses.
6. Pandemic Adaptability: This feature guarantees care continuity in the event of lockdowns or medical emergencies.

Tele-prosthodontics' drawbacks
1. Technical Restrictions -Reliance on sophisticated digital tools and fast internet, which might not be accessible everywhere.
2. Limited Physical Assessment: Due to the inability to physically check patients, clinicians may overlook important information.
3. Data Security Risks: Without appropriate encryption and compliance, patient data transferred digitally is vulnerable to breaches.
4. Initial Costs: For smaller clinics, the cost of training and telecommunications technology may be prohibitive.
5. Limited Scope: Precise execution of complex operations, such as full-mouth rehabilitation, necessitates in-person visits.

Tele-Prosthodontic Applications Examples
1. Rural Clinics: For complex prosthesis situations, dentists in rural areas consult with specialists remotely.
2. Patients with disabilities and the elderly. Patients who are confined to their homes can obtain consultations without having to leave.
3. Multidisciplinary Cases: Prosthodontists, orthodontists, and periodontists work together in real time to provide integrated care.
4. Dental Tourism-Prior to their trip, foreign patients can have consultations and preliminary treatment planning done virtually.

One promising way to close the gap between patients and specialized care is through tele-prosthodontics. Although technology cannot entirely replace face-to-face contacts in complex cases, it is a vital tool in contemporary prosthodontic practice because of its capacity to increase accessibility, collaboration, and efficiency. Its potential is further increased by combining AI with digital workflows and immersive technologies.
Examples of Dental Remote Monitoring Software
Without the need for in-person visits, dentists can use remote monitoring software to monitor patient progress, assess treatments, and ensure continuity of care. Here are a few noteworthy instances of platforms and software that are frequently utilized in prosthodontics and dentistry: **[27-29]**

1. Dental Observation
• Synopsis: AI-driven software for remote orthodontic and prosthodontic treatment monitoring.
• Features: Makes use of photos uploaded by patients' smartphones.
AI evaluates the effectiveness of treatment and notifies doctors of problems.
It makes virtual check-ins easier.
• Prosthodontic Use Case: Tracking implant healing or the fit and adaption of detachable prostheses.

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2. The CS Remote View from Carestream Dental
• Description: An intraoral picture and scan sharing program that runs on the cloud.
• Features: o Gives doctors remote access to radiographs and patient photos.
o Facilitates group case reviews.
• Prosthodontic Use Case: Post-treatment assessments and correspondence between specialists and referring dentists.

3. Align Technology's My Invisalign software: This patient-focused software allows users of transparent aligners to track their progress.
• Features: o Patients submit pictures for evaluation.
o The treatment plan is compared to the progress.
• Prosthodontic Use Case: Adaptable for occlusal guards or detachable partial dentures.

4. Teledentix • Description: All-inclusive tele-dentistry software that allows for remote monitoring and consultations.
• Features: o Video calls and secure messaging.
o Integration of patient records.
o Progress monitoring using electronic documents.
• Prosthodontics Use Case: Assists in monitoring healing following implant surgery or remotely modifying treatment regimens.

5. Remote Monitoring with Grin
• Description: A proprietary scanning tool for patients is used by this orthodontic-focused monitoring platform.
• Features: o Patient-portable intraoral cameras.
o AI evaluation of advancement.
Clinical dashboards for convenient monitoring.
• Prosthodontics Use Case: Keeping an eye on the gingival health surrounding implants or prostheses.

Benefits of Software for Remote Monitoring
1. Convenience for Patients
• Saves time and money on travel by doing away with the necessity for regular in-person visits.
2. Early Problem Detection: AI and routine remote evaluations aid in the early detection of problems such as misaligned prostheses, implant infections, and inappropriate fits.
3. Clinician Efficiency: This feature enables doctors to do routine follow-ups remotely while concentrating on important in-person situations.
4. Improved Patient Engagement Patients are kept informed and involved in their care process through real-time updates and visualizations.
5. Cost-Effectiveness • Minimizes chair time for non-essential appointments and lowers overhead expenses for clinics.
6. Continuity of Care: This guarantees continued care and observation in the event of pandemics or patient relocations.
7. Benefits to the Environment: • Reduces the carbon footprint caused by patients traveling to clinics.

Restrictions to Consider
1. Technological Barriers: Patients must have internet access and compatible gadgets.
2. Learning Curve: To use the platforms efficiently, physicians and patients alike need training.
3. Privacy Issues: Regulations such as GDPR and HIPAA must be followed when handling sensitive patient data.
4. Limited Physical Examination: It cannot completely take the place of physical adjustments or tactile evaluation.
In contemporary prosthodontics, remote monitoring software is becoming essential because to its substantial advantages in patient happiness, accessibility, and efficiency. It is anticipated that these solutions will become more useful as AI and data security advances, enhancing conventional dentistry workflows.

The Benefits of Simulation-Based Training [23,28,30-32]
1. Risk-free skill development
• Practice without endangering patients: Clinicians can perform prosthodontic operations (such crown preparation, bridge placement, and implant restoration) in a risk-free environment via simulation-based training. This lessens the possibility of hurting patients and helps avoid mistakes in actual clinical settings.
• As an illustration, dental students can practice crown preparation on a virtual environment or 3D-printed model before doing the treatment on a real patient.

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2. Techniques Repetition and Mastery
• Practice under control: Prolonged practice in simulation environments increases procedural accuracy and helps people grasp complex tasks. Prior to interacting with actual patients, learners can gain proficiency by regularly doing tasks such as producing dentures or installing crowns through simulation.
• For instance, in virtual environments, a clinician can repeatedly practice implant insertion and improve the skill without worrying about the real-world repercussions.

3. Immediate Performance Assessment and Feedback- Analysis in real time: Feedback mechanisms are frequently integrated into simulation systems so that students can get real-time performance data. These systems evaluate technique, accuracy, and movements, giving useful information for development.
• As an illustration, a prosthodontic student undergoing virtual reality training may get immediate feedback on how well their crown was prepared in accordance with predetermined accuracy requirements.

4. Increases Self-Belief and Lowers Anxiety
• Increases self-confidence: Dental practitioners can execute intricate prosthodontic treatments with more accuracy by rehearsing in a simulated setting. When interacting with patients in the real world, this boosted confidence helps lessen performance anxiety.
• For instance, doctors can feel less nervous and more at ease when performing implant surgery on real patients by using virtual simulations of the procedure.

5. Acquiring Knowledge at Your Own Speed
• Adaptable learning: Simulation-based learning environments let students practice at their own speed. In prosthodontics, where sophisticated treatments might have a high learning curve, this is very helpful. By repeating the same process as often as necessary, learners can advance their technical proficiency.
• For instance, without the stress of patient appointments, a dental student can practice taking digital impressions for dentures as often as needed.

6. Getting Ready for Complex or Seldom Occurring Cases
• complicated scenario exposure: Training through simulation can mimic complicated or uncommon clinical cases, which may not happen often in a clinical context but are crucial for mastery.
• For instance, prosthodontists can practice emergency implant insertion or rehabilitation of severely impaired dentition through simulation, which may not occur frequently in their daily work.

7. Strengthens Critical Thinking and Decision-Making
• Interactive learning: Complex simulations present situations with crucial choices, such managing unforeseen consequences or modifying treatment regimens. For prosthodontic results to be effective, practitioners need to be able to think critically and make judgments quickly.
• As an illustration, a simulation might show a situation in which the initial prosthesis does not fit well, necessitating that the doctor modify the treatment strategy and perform troubleshooting in a safe, virtual setting.

8. Promotes Interdisciplinarity in Cooperation
• Collaborative learning: Teams of dental specialists, such as prosthodontists, periodontists, and orthodontists, can be trained jointly using simulation-based platforms. When handling difficult issues, this cooperative method promotes coordination and communication.
• As an illustration, prosthodontists and periodontists can work together on a case involving implant placement and restoration using virtual platforms, which enable them to see and discuss treatment options in real time.

Benefits of Training Through Simulation
1. Better Skill Acquisition-Offers repeated practice that speeds up learning and improves output.
2. Risk Minimization-Lowers the possibility of making mistakes with actual patients.
3. Effective for All Learning Levels-Helpful for clinicians who wish to improve their skills, regardless of experience level.
4. Realistic Experience-Simulations are made to faithfully mimic clinical settings, which improves the educational process.
5. Cost and Time Efficiency-Makes learning in a more regulated and time-efficient setting possible by eliminating the need for lengthy clinical hours.

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The drawbacks of training by simulation

1. Expensive upfront expenses- The hardware and software required to build up simulation-based systems might be costly.
2. Restrictions in Technology - Certain parts of skill development may be limited by simulators that don't accurately mimic the tactile sensations of working on actual patients.
3. The Learning Curve for Technology-Clinicians may need more time and training to get used to simulation systems.
4. Restricted Range of Complex operations: Present technology may not be able to adequately imitate some high-level operations just now.

In prosthodontics, simulation-based training is a vital tool that offers substantial advantages in patient safety, decision-making, and skill acquisition. It gives practitioners immediate feedback while enabling them to hone their abilities in a risk-free setting. Although there are drawbacks, including as expenses and technological constraints, the benefits—especially with regard to enhancing procedural proficiency and lowering anxiety—make it an essential part of contemporary dental education.

Prosthodontic Predictive Analytics

In prosthodontics, predictive analytics uses data, algorithms, and machine learning models to predict results, optimize treatment regimens, and enhance patient care. These technologies predict the outcome of prosthodontic procedures including crowns, bridges, implants, and dentures by utilizing a variety of patient data sources, including digital impressions, radiographs, clinical history, and anatomical features. Some of the predictive analytical methods that are being utilized more and more in prosthodontics are listed below: **[23,25-27]**

1. Implant Success Predictive Models

• Use: Using variables like bone density, implant size, location, and patient medical history, predictive analytics can be utilized to determine the probability of implant success or failure. These technologies find patterns in vast datasets that might be missed in clinical practice.

• As an illustration, software such as Simplant forecasts the likelihood of implant integration and possible issues using cone beam computed tomography (CBCT) data, patient medical records, and implant factors.

2. Using Digital Impressions to Predict Prosthetic Success

• Use: Prosthetic repair fit and functionality can be predicted using digital impressions and predictive analytics. Software can forecast the possibility of requiring changes after installation by evaluating prior cases and gauging the accuracy of the digital imprints.

• For instance, CAD/CAM systems employ algorithms to evaluate the likelihood of a successful prosthetic implantation based on variables including alignment with the remaining natural teeth, occlusion, and crown margins.

• Use: Occlusal connections, or how teeth align and interact, can be analyzed by predictive techniques to predict possible problems such prosthesis wear, dysfunction, or failure. These instruments take into account the patient's chewing habits, bite force distribution, and jaw movements.

• For instance, kinematic models are used by software such as Orognathic Simulation Systems (OSS) to forecast occlusal stability and functional results in patients in need of full-mouth rehabilitations.

Articulators and Virtual Facebows

For prosthetics to be functional, the maxillary and mandibular arches must be precisely articulated and positioned. The occlusal and jaw movement patterns of the patient are replicated with the aid of conventional facebows and articulators. Digital articulators and virtual facebows, on the other hand, have completely changed this area of prosthodontics by providing accurate measurements, less discomfort for patients, and more consistent outcomes.

1. Facebow Systems that are virtual

The link between the patient's maxillary arch and temporomandibular joint (TMJ) is transferred to an articulator using a facebow. Instead of employing conventional mechanical techniques to capture this relationship, virtual facebow systems use digital technology, which improves accuracy and streamlines the procedure.

Benefits:

• Accuracy: Virtual facebows make it possible to communicate jaw connection data more precisely by doing away with the necessity for real impressions. Because digital records can be obtained more rapidly than old facebow procedures, the process is quicker. Compared to classic facebow devices, digital impressions cause less discomfort.

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• Integration with CAD/CAM: Virtual facebow data may be easily included into CAD/CAM systems to enable highly accurate prosthesis design. • For instance, the virtual facebow feature of the 3Shape TRIOS intraoral scanner allows for the digital capturing of the patient's maxillo-mandibular connection straight from the intraoral scan.

Drawbacks:

• Technology Dependency: Necessitates significant training and investment in digital technology. Because of financial and technological constraints, not many dentist offices have access to cutting-edge virtual facebow systems.

2. Articulators that are digital

Prosthodontists can mimic occlusion and modify prosthetic designs by using a digital articulator, which digitally replicates the patient's jaw movement. These technologies are completely integrated with digital workflows and take the role of conventional mechanical articulators.

Benefits:

By mimicking intricate jaw movements that conventional systems would not be able to reproduce, digital articulators provide more accurate articulation of dental restorations. Time Because physical models don't need to be manually adjusted, this method is quicker than traditional articulators. Treatment planning and prosthesis design are improved by the capacity to see occlusion in three dimensions.

• As an illustration, the KaVo Arctica digital articulator system simulates jaw movements and forecasts how the prosthesis will interact with the patient's occlusion using 3D scans and virtual models. The purchase and upkeep of digital articulators are costly. May involve a learning curve for practitioners who are not experienced with digital systems and need training to operate.

• A restricted ability to integrate with non-digital systems Digital articulators are not always easy to combine with other systems or labs.

3. Combining Digital Articulators and Virtual Facebows

Digital articulators and virtual facebows work together to improve prosthodontic treatment planning accuracy. Prosthodontists can now precisely model occlusion and jaw movements thanks to this integration, providing specialized solutions for challenging situations.

Benefits:

High accuracy and efficiency are ensured by streamlining the process from diagnosis to final prosthesis design through the integration of virtual facebows with digital articulators. Accurate occlusal planning results in prostheses that work better and require fewer revisions or remakes. Enhances patient-specific personalization by enabling real-time prosthesis modifications during virtual simulations.

• For instance, to create restorations with the best possible occlusion and function, the Exocad DentalCAD system interfaces with virtual facebows and articulators. Many dental practices may find these integrated systems to be unaffordable, which restricts their use. If a practitioner relies too heavily on digital systems, they may not be able to work when the digital process is unavailable.

The precision, effectiveness, and predictability of prosthodontic procedures are greatly improved by predictive analytics and digital technology, such as digital articulators and virtual facebows. Particularly in complicated situations requiring exact occlusion and prosthesis fit, these technologies enable improved treatment planning, reduce errors, and enhance patient outcomes. Despite their expenses and technological difficulties, they are crucial elements of contemporary prosthodontic practice because of the advantages they provide in terms of clinical accuracy and patient satisfaction.

II. CONCLUSION

Prosthodontics' use of virtual reality has revolutionized restorative dentistry by providing notable advancements in prosthesis design, treatment planning, and diagnostic precision. Predictive analytics, virtual facebows, and CAD/CAM systems are examples of digital technology that have improved workflows, decreased patient suffering, and guaranteed more accurate restorations. In addition to improving clinical results, these improvements increase therapy flexibility and efficiency, which raises patient happiness. Even if there are still issues like high upfront costs and the requirement for specialized training, these can be resolved with further technical advancement and broad use. A more effective and patient-centered approach to restorative dentistry is anticipated as a result of the future integration of artificial intelligence and sophisticated simulation systems, which should further improve the precision and personalization of prosthodontic care.

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REFERENCES

1. Mangano, F. et al. (2021). Accuracy of Intraoral Scanners in Prosthodontics. Journal of Prosthodontics.
2. Revilla-León, M., & Özcan, M. (2020). Economic Impact of Digital Technologies in Prosthodontics. Journal of Dental Research.
3. Ender, A., Attin, T., & Mehl, A. (2016). Intraoral Scanning: Accuracy of Complete-Arch Impressions and Implications for Clinical Use. Quintessence International.
4. Abduo, J., Bennamoun, M., & Tennant, M. (2019). Accuracy of Virtual Treatment Planning in Fixed Prosthodontics. Journal of Prosthetic Dentistry.
5. Revilla-León, M., & Özcan, M. (2021). Cost Analysis of Virtual Simulations in Dentistry. Journal of Esthetic and Restorative Dentistry.
6. Chochlidakis, K. M., Papaspyridakos, P., & Ercoli, C. (2016). Digital Workflow in Prosthodontics: A Review. Journal of Prosthodontics.
7. Zafar, M. S., et al. (2020). Digital vs Traditional Wax-Ups in Prosthodontics: A Comparative Review. Journal of Prosthetic Dentistry.
8. Neumeier, T., & Mehl, A. (2014). Digital vs. Conventional Techniques for Wax-Ups in Prosthodontics. International Journal of Prosthodontics.
9. Alharbi, N., Wismeijer, D., & Osman, R. (2016). Applications of 3D Printing in Prosthodontics: A Review. Journal of Prosthetic Dentistry.
10. Van Noort, R. (2012). The Future of Additive Manufacturing in Dentistry. Dental Materials.
11. Revilla-León, M., & Özcan, M. (2021). Additive Manufacturing Technologies in Dentistry. Clinical Oral Investigations.
12. Miyazaki, T., Nakamura, T., Matsumura, H., Ban, S., & Kobayashi, T. (2013). CAD/CAM Systems in Dentistry: Past, Present, and Future. Journal of Prosthodontic Research.
13. Bindl, A., & Mörmann, W. H. (2005). Clinical Performance of Milled CAD/CAM Restorations: A 5-Year Retrospective Study. Journal of the American Dental Association.
14. Abduo, J., Lyons, K., & Bennamoun, M. (2014). Trends in Computer-Aided Manufacturing in Prosthodontics: A Review. Journal of Prosthodontics.
15. Patel, N., et al. (2020). Cost-Effectiveness of Digital Dentistry: A Review. Journal of Prosthetic Dentistry.
16. Schwendicke, F., et al. (2020). Artificial Intelligence in Dentistry: Diagnostic and Prognostic Applications. Journal of Dental Research.
17. Wismeijer, D., et al. (2016). The Role of Digital Dentistry in Prosthodontics. International Journal of Prosthodontics.
18. Logeswaran, R., et al. (2020). Virtual Reality in Dental Education: Current Perspectives. Journal of Dental Education.
19. Tanja-Dijkstra, K., et al. (2018). The Use of Virtual Reality for Dental Anxiety Management. Journal of Anxiety, Stress, & Coping.
20. Gupta, R., et al. (2020). Efficacy of Virtual Reality Distraction in Pediatric Dentistry. Journal of Dental Research.
21. Lin, P., et al. (2022). Virtual Reality Applications in Dental Clinics. Clinical Oral Investigations.
22. Ryding, R., et al. (2021). Immersive Technologies in Dentistry: A Systematic Review. Journal of Prosthetic Dentistry.
23. Ghai, S. (2020). Tele-Dentistry During COVID-19 Pandemic. Journal of Oral Biology and Craniofacial Research.
24. Estai, M., et al. (2018). A Systematic Review of the Research on Tele-Dentistry. Telemedicine and e-Health.
25. Arheiam, A., et al. (2020). Tele-Dentistry in Remote Prosthodontic Practice: Challenges and Opportunities. International Journal of Prosthodontics.
26. Wismeijer, D., et al. (2016). Digital Innovations in Prosthodontics. International Journal of Prosthodontics.
27. Estai, M., et al. (2018). A Systematic Review of the Research on Tele-Dentistry. Telemedicine and e-Health.
28. Logeswaran, R., et al. (2020). Virtual Reality and Remote Monitoring in Dentistry. Journal of Dental Education.
29. Wismeijer, D., et al. (2016). Digital Innovations in Prosthodontics. International Journal of Prosthodontics.
30. Estai, M., et al. (2018). A Systematic Review of the Research on Simulation-Based Training in Dentistry. Telemedicine and e-Health.
31. Wismeijer, D., et al. (2016). Digital Innovations in Prosthodontics: The Role of Simulation-Based Training. International Journal of Prosthodontics.
32. Ryding, R., et al. (2021). Simulation for Critical Thinking and Decision-Making in Dental Education. Journal of Prosthetic Dentistry.

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