THE EVOLVING ROLE OF ARTICULATORS IN PROSTHETIC AND RESTORATIVE DENTISTRY: A REVIEW

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ABSTRACT

The articulator, in its mechanical or virtual form, remains fundamental to the successful execution of prosthetic and restorative dentistry. From the basic hinge of a simple articulator to the complex, individualized kinematics of a virtual articulator, this instrument allows the dentist and technician to simulate and analyse the intricate movements of the jaw outside the patient's mouth. While traditional mechanical articulators, particularly the semi-adjustable type, continue to serve as the workhorse for routine cases, the virtual articulator represents the future.

Keywords: Articulator, Non-adjustable articulators, Semi-adjustable articulators, Digital Workflow.

INTRODUCTION

The success of any extensive prosthetic or restorative dental treatment, whether fixed or removable, is intrinsically linked to the accurate replication and analysis of the patient's occlusal relationship and mandibular movements. The dental articulator, defined as a mechanical instrument that represents the temporomandibular joints and jaws, allows maxillary and mandibular casts to be attached to simulate mandibular movements, is an indispensable tool in achieving this goal [(1).]

Its function is to facilitate the design and fabrication of restorations that harmonize with the patient's stomato gnathic system, preventing occlusal disharmony and subsequent complications like pain, excessive wear, and failure of the restoration [(2,3).]

THE CONVENTIONAL MECHANICAL ARTICULATOR

Historically, mechanical articulators have been categorized based on their ability to simulate movement: non-adjustable (hinge/simple), mean-value (non-adjustable), semi-adjustable, and fully-adjustable [(2).]

- **Non-adjustable articulators** function primarily as a simple hinge, only capable of replicating the static intercuspal position. They are generally only suitable for single-tooth restorations where minimal occlusal change is anticipated [(2).]

  Clinical Role: Their primary use is for single crowns, small bridges, or diagnostic casts where the occlusal vertical dimension (OVD) is not being changed and the lateral excursive movements of the opposing arch are minimal or not critical to the design.

Limitation: They assume average values for condylar inclination (around 30^0 and the distance between the hinge axis and the incisal point, ignoring the patient's unique anatomy. This reliance on average values significantly increases the risk of occlusal errors in complex restorations, necessitating time-consuming and destructive chair-side grinding (equilibration) [(3).]

- Semi-adjustable articulators allow for the adjustment of some condylar path elements (e.g., condylar inclination, Bennett angle) using average or patient-specific records derived from a facebow and bite registrations. These are commonly used for most fixed and removable prosthetic cases, offering a balance between accuracy and clinical feasibility [(3).] The Arcon (articular/condyle) and Non-arcon (non-articular/condyle) designs differ in how the mechanical condylar elements are fixed, which impacts the accuracy of movement simulation, especially in relation to the vertical dimension of occlusion [(4).]
- Fully-adjustable articulators are designed to replicate the patient's complete mandibular movement paths with a high degree of precision, often utilizing electronic or pantographic tracings to set individual condylar controls. While offering the highest potential accuracy, their use is typically reserved for complex cases, such as full-mouth rehabilitation or treatment of temporomandibular disorders, due to their complexity, time-intensive procedures, and cost [(3,5).]

Despite their utility, mechanical articulators face inherent limitations, including manufacturing inaccuracies, wear over time, and the inability to perfectly replicate the elasticity and dynamic nature of the human tissues and musculature. They primarily simulate border movements rather than the functional chewing cycles [(1,3).]

THE EMERGENCE OF THE VIRTUAL ARTICULATOR

The advent of digital dentistry and Computer-Aided

Design/Computer-Aided Manufacturing (CAD/CAM) systems has introduced the virtual articulator(VA), a software-based tool that simulates the functions of a mechanical articulator in a three-dimensional digital environment[6].

The virtual articulator represents a significant leap forward, aimed at reducing the limitations of its mechanical predecessor[1].

DIGITAL WORKFLOW AND FUNCTION

The workflow for a VA typically involves:

1. **Digital Acquisition:** Intra-oral scanners (direct digitizing) or laboratory scanners (indirect digitizing of casts) capture the 3D geometry of the dental arches [1].
2. **Jaw Motion Tracking:** Patient-specific dynamic movements are recorded using electronic systems, such as a Jaw Motion Analyzer (JMA), which often employs ultrasound technology to track the mandibular position in three dimensions relative to the maxilla[1,6].
3. **Virtual Mounting:** The digital models are virtually 'mounted' within the VA software, allowing for the simulation of static and dynamic occlusion based on the captured data [1,7].

ADVANTAGES IN PROSTHETIC AND RESTORATIVE DENTISTRY

The virtual articulator offers several advantages that enhance the quality and predictability of restorative and prosthetic work:

- **Precision and Customization:** VAs can incorporate highly individual patient data, allowing for a more accurate and patient-specific analysis of occlusal contacts during various excursive movements, which is crucial for the optimal design of crowns, bridges, and dentures [7,8].
- **Diagnostic Enhancement:** The software provides a dynamic, three-dimensional visualization of occlusal interferences and guidance paths, aiding in diagnosis and treatment planning—particularly in cases involving changes to the vertical dimension of occlusion[3,8].
- **Improved Communication and Education:** The 3D visualization acts as an excellent communication tool between the clinician, the dental technician, and the patient, enhancing the design process and patient understanding[1].
- **Efficiency:** Integrating the VA into the CAD/CAM workflow streamlines the process of restoration design and adjustment, potentially reducing chair-side time for occlusal adjustments[1,7].

Virtual articulators are broadly classified into mathematically simulated (MS), which mimic the movements of a conventional articulator, and completely adjustable (CA), which use patient-specific movement data for a highly customized simulation [6]. The utility of the VA is particularly notable in complex cases, where precise replication of mandibular movement is essential to avoid potential occlusal pathologies in the final restoration[3,5].

CONCLUSION

The articulator, in its mechanical or virtual form, remains fundamental to the successful execution of prosthetic and restorative dentistry. From the basic hinge of a simple articulator to the complex, individualized kinematics of a virtual articulator, this instrument allows the dentist and technician to simulate and analyse the intricate movements of the jaw outside the patient's mouth. While traditional mechanical articulators, particularly the semi-adjustable type, continue to serve as the workhorse for routine cases, the virtual articulator represents the future. Its ability to integrate high-fidelity, patient-specific motion data into the digital CAD/CAM workflow offers unparalleled precision and efficiency, promising superior functional and aesthetic outcomes in restorative and prosthetic treatments[1,6,7].

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