



Short Review

Beyond Force: The Science of Biomechanics in Modern Dentistry

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Abstract

Biomechanics in dentistry is the application of mechanical principles to understand how forces interact with teeth, periodontal tissues, dental implants, restorative materials, and the surrounding oral structures. It plays a fundamental role in diagnosis, treatment planning, restorative dentistry, orthodontics, prosthodontics, implant dentistry, and oral rehabilitation. The oral cavity is continuously exposed to complex forces generated during mastication, swallowing, speech, parafunctional activities, and tooth movement. Understanding the magnitude, direction, distribution, and duration of these forces is essential for maintaining biological health and achieving long-term treatment success. Dental biomechanics integrates concepts such as stress, strain, force, torque, leverage, friction, elasticity, and material behavior to predict the response of biological and artificial structures. Advances in digital dentistry, finite element analysis, computer-aided design and manufacturing, and three-dimensional imaging have further enhanced the ability to evaluate biomechanical behavior. This article reviews the fundamental principles of biomechanics in dentistry and discusses their clinical significance in restorative dentistry, orthodontics, prosthodontics, and implantology. A sound understanding of biomechanics enables clinicians to design treatments that distribute forces appropriately, minimize tissue damage, improve function, and enhance the longevity of dental restorations and prostheses.

Introduction

Dentistry is not only concerned with the prevention and treatment of oral disease but also with restoring the function, stability, and structural integrity of the

stomatognathic system. Every dental treatment alters, to some extent, the way forces are transmitted through teeth and surrounding tissues. Biomechanics provides the scientific framework for understanding these interactions.

Biomechanics can be defined as the application of principles of mechanics to biological systems. In dentistry, it examines how teeth, periodontal tissues, bone, dental implants, restorations, and prostheses respond to external and internal forces.

The importance of biomechanics becomes particularly evident when considering that teeth are subjected to repeated loading throughout life. A restoration that appears clinically acceptable may fail if the forces acting on it are not properly considered. Similarly, excessive or poorly directed forces around an implant may contribute to mechanical complications or biological problems.

Therefore, biomechanical principles are central to designing dental treatments that are functional, stable, biologically compatible, and durable.

Biomechanics of Natural Teeth

Natural teeth are supported by the periodontal ligament and alveolar bone. The periodontal ligament acts as a specialized connective tissue between the tooth root and surrounding bone

During normal function, occlusal forces are transferred from the crown through the root to the periodontal ligament and alveolar bone. The periodontal ligament

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helps distribute these forces and provides a degree of physiological mobility.

The shape and orientation of the periodontal ligament, root morphology, alveolar bone architecture, and direction of loading all influence stress distribution

Clinical significance

Understanding natural tooth biomechanics helps clinicians:

- Design appropriate occlusal contacts.
- Reduce excessive loading.
- Plan restorations.
- Evaluate tooth mobility.
- Preserve periodontal support.
- Manage occlusal trauma.

Biomechanics in Restorative Dentistry

Restorative procedures modify the natural anatomy and mechanical behavior of teeth. The restoration must withstand repeated functional forces while preserving the remaining tooth structure

Cavity preparation

The amount of tooth structure removed during preparation can significantly influence the mechanical strength of the remaining tooth.

Conservative preparation techniques aim to preserve healthy enamel and dentin while providing sufficient space for restorative material.

Material selection

Different restorative materials have different mechanical properties, including:

- Elastic modulus
- Fracture resistance
- Hardness
- Toughness
- Wear resistance

The selection of a material should consider the location of the restoration, expected occlusal forces, remaining tooth structure, and functional requirements

Stress concentration

Sharp internal angles and abrupt changes in geometry can create areas of stress concentration. Rounded internal line angles and appropriate preparation designs can help reduce localized stress

Future Perspectives

The future of dental biomechanics is closely associated with digital technologies, computational modeling, artificial intelligence, and personalized dentistry

Patient-specific three-dimensional models may allow clinicians to simulate treatment conditions before treatment begins. Integration of CBCT data, intraoral scans, digital occlusal information, and computational analysis could facilitate individualized assessment of force distribution.

Conclusion

Biomechanics provides an essential scientific foundation for modern dentistry. From the natural tooth-periodontal ligament complex to dental implants, orthodontic appliances, restorations, and prostheses, every component of oral rehabilitation is influenced by mechanical forces. Understanding force, stress, strain, torque, material properties, and load distribution enables clinicians to design treatments that respect both mechanical and biological principles. Advances in finite element analysis, digital dentistry, three-dimensional imaging, and computer-assisted treatment planning are expanding the possibilities for biomechanical evaluation

Ultimately, successful dental treatment requires more than simply restoring anatomy. It requires consideration of how forces are generated, transmitted, absorbed, and distributed within the oral environment. Integrating biomechanics with biological knowledge and clinical experience can contribute to predictable function, structural preservation, and long-term treatment outcomes.

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