Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v29i04.5928

ADVANCEMENTS IN ORTHODONTIC MATERIALS: A REVIEW OF INNOVATIONS IN WIRES AND BRACKETS

Ebtisam Salman Al Saeed[1*], Hassan Mohammed H Alharthi[2], Zahra Ali Al Ibrahim[3], Nahla Manie Alghamdi[4], Hussain Zaki Al Abdulwahhab[5], Mahdi Mordi Alanazi[4], Abdulaziz Ibrahim Aljabr[6], Essa Mohammed Hakami[7], Ghada Saad Saleh Alshohaib[8], Mislat Saad Almutairi[9], Faisal Hamad Alyahya[10]

[1*]Primary Healthcare Center, Ministry of Health, Qatif, Saudi Arabia
[2]AlMoaqqas Primary Healthcare, Ministry of Health, Alqunfudhah, Saudi Arabia
[3]Dental Assistant, Ministry of Health, Qatif, Saudi Arabia
[4]General Dentist, Ministry of Health, Qassim, Saudi Arabia
[5]Department of Dentistry, Al Qatif Central Hospital, Qatif, Saudi Arabia
[6]Dental Department, West Riyadh Dental Center, Ministry of Health, Riyadh, Saudi Arabia
[7]Dental Clinic, Ministry of Health, Jazan, Saudi Arabia
[8]Dental Department, Ministry of Health, Jeddah, Saudi Arabia
[9]Buraidah Central Hospital, Ministry of Health, Buraidah, Saudi Arabia
[10]Department of Dentistry, King Fahad Hospital (Second Cluster), Riyadh, Saudi Arabia

***Corresponding Author:** Ebtisam Salman Al Saeed
*Primary Healthcare Center, Ministry of Health, Qatif, Saudi Arabia,
email: ealsaeed_ebtisam@hotmail.com

Abstract

Recent advancements in orthodontic materials, particularly in wires and brackets, have significantly enhanced both clinical outcomes and patient comfort. Innovations in materials such as nickel-titanium alloys and ceramic composites have brought forth improvements in mechanical properties and aesthetic qualities, meeting the rising patient demand for less conspicuous orthodontic devices. Enhanced flexibility, strength, and a more natural appearance characterize these new materials, contributing to their growing adoption in modern orthodontic practices. Technological enhancements in bracket design, driven by computer-aided design (CAD) and 3D printing, facilitate the production of customized brackets. These tailor-made solutions fit more precisely, reducing treatment time and improving patient comfort. Additionally, the use of digital technologies in treatment planning, including digital shavening and virtual simulations, has not only enhanced the predictability of treatment outcomes but also increased patient satisfaction and engagement. The introduction of softer and more adaptable wire materials has been pivotal in reducing the incidence of adverse effects such as root resorption, thereby improving the safety and comfort of orthodontic treatments. Emphasizing a patient-centered approach, the field of orthodontics now prioritizes materials that achieve effective results while satisfying aesthetic and comfort needs. The shift towards incorporating advanced materials and technologies marks a significant evolution in the field of orthodontics. Ongoing research and development are crucial for further improvements, ensuring that orthodontic treatment remains at the forefront of technological innovation. These developments not only promise more efficient, comfortable, and aesthetically pleasing treatment options but also underscore the importance of aligning clinical practice with patient expectations and well-being.

Keywords: Orthodontic, materials, wires, brackets

Introduction

Orthodontics has experienced remarkable progress in recent years, primarily due to significant advancements in material sciences and technology. The development of new orthodontic materials, especially in the realm of wires and brackets, has transformed treatment modalities and outcomes. Traditional materials, while effective, often presented challenges such as discomfort, prolonged treatment times, and aesthetic concerns (1). Recent innovations aim to address these issues by enhancing the physical and mechanical properties of orthodontic wires and brackets, thus improving patient compliance and satisfaction.

The introduction of novel materials such as shape-memory alloys and biocompatible polymers has revolutionized the field. These materials adapt to intraoral conditions, maintain consistent force over extended periods, and reduce the frequency of clinical adjustments (2). Moreover, the evolution of bracket design, integrating principles from nanotechnology and computer-aided design, has allowed for more precise and efficient tooth movement. This technological leap not only speeds up the alignment process but also enhances overall treatment accuracy (3). Patient-centered considerations have also steered recent advancements. The demand for less visible orthodontic appliances has led to the development of aesthetically pleasing materials that blend seamlessly with the natural color of teeth. Furthermore, the focus on reducing discomfort has prompted the creation of softer, more flexible wires that minimize the pressure exerted on the teeth and surrounding tissues (4).

The ongoing research and development in orthodontic materials not only promise to enhance clinical outcomes but also aim to make orthodontic treatment a more appealing and bearable experience for patients. This review will delve into the latest innovations in wires and brackets, discussing their material composition, technological enhancements, and their impact on clinical practice and patient experiences.

Methods

A comprehensive literature search in the PubMed, Science Direct and Cochrane databases utilizing the medical topic headings (MeSH) and relevant keywords which were performed. All relevant peer-reviewed articles involving human subjects and those available in the English language were included. Using the reference lists of the previously mentioned studies as a starting point, a manual search for publications was conducted through Google Scholar to avoid missing any potential studies. There were no limitations on date, publication type, or participant age.

Discussion

The continuous evolution of orthodontic materials, specifically wires and brackets, has significantly influenced both the clinical practices and the patient's experiences in orthodontics. One of the most notable advancements is in the material composition of orthodontic wires. The introduction of innovative alloys, such as nickel-titanium (NiTi), has allowed for the development of wires that can deliver light, continuous forces over a longer period without frequent activation. This is crucial in reducing the overall treatment time and enhancing patient comfort by minimizing the discomfort typically associated with tighter adjustments (5).

Furthermore, the shift towards patient-centered orthodontic care has catalyzed the development of brackets that are not only functional but also aesthetically pleasing. The advent of ceramic brackets is a prime example. These brackets offer a color and transparency that mimic the natural tooth, providing an orthodontic solution that is less noticeable than traditional metal brackets. This has been particularly appealing to adult patients who are concerned about the visibility of orthodontic appliances during professional interactions or social engagements (6). These advancements highlight the dynamic nature of orthodontic material technology and underscore the importance of continuous research to refine and enhance the materials used. Such developments not only aim to improve the mechanical and aesthetic aspects of orthodontic treatments but also focus on the psychosocial impacts, ensuring that patients receive both effective and discreet care.

Material Composition and Mechanical Properties

The development and enhancement of orthodontic materials, particularly in the context of wires and brackets, have been pivotal in advancing orthodontic treatment efficiencies and outcomes. The core of these advancements lies in the strategic manipulation of material composition and the optimization of their mechanical properties. Contemporary orthodontic wires are predominantly made from high-tech alloys such as nickel-titanium (NiTi) and stainless steel, with each material offering distinct mechanical benefits tailored to different stages of treatment.

Nickel-titanium alloys, known for their superelasticity and shape memory properties, are especially valuable in the initial phases of orthodontic treatment where gentle, yet consistent, forces are necessary to move teeth effectively and comfortably. The superelasticity allows these wires to maintain a constant force despite significant bending and deformation, reducing the need for frequent adjustments and thereby enhancing patient comfort (7). This property is critical in managing complex tooth movements with minimal discomfort and tissue damage. On the other hand, stainless steel wires, which are traditionally used during the later stages of treatment, are valued for their rigidity and strength. These characteristics are crucial when more substantial forces are required to fine-tune tooth positioning. Stainless steel's robust nature allows for precise control over tooth movement, a vital factor in achieving optimal alignment and occlusion (8).

The brackets, which hold the wires against the teeth, have also seen significant material innovation. The use of polycrystalline and monocrystalline ceramic materials for brackets has grown in popularity due to their aesthetic qualities and robust mechanical properties. Ceramics provide a balance between strength and aesthetic appeal, resisting staining while being strong enough to withstand the forces exerted during orthodontic treatments. However, advancements in the manufacture and design of ceramic brackets have also focused on reducing their brittleness—a traditional drawback—thereby enhancing their durability and reducing the risk of bracket fracture during treatment (9). These material advancements in wires and brackets not only improve the mechanical effectiveness of orthodontic devices but also significantly influence treatment outcomes. The ongoing innovation in the material science of orthodontics is a testament to the field's commitment to improving patient experiences and clinical results through engineering and technology.

Technological Enhancements in Bracket Design

In the field of orthodontics, the design of brackets has undergone transformative changes, thanks to advancements in technology and materials science. Modern bracket design not only focuses on improving mechanical efficiencies but also on enhancing patient comfort and treatment aesthetics. The integration of cutting-edge technologies such as computer-aided design (CAD) and 3D printing has played a pivotal role in these developments. One of the most significant technological enhancements in bracket design is the use of CAD/CAM systems. These systems allow for the precise and customized fabrication of brackets according to the anatomical requirements of each patient. This customization ensures a better fit and more effective force application, leading to improved alignment efficiency and reduced treatment times (10). Moreover, CAD/CAM technology facilitates the creation of low-profile brackets, which are less obtrusive and more comfortable for the patient, significantly enhancing the overall treatment experience.

Additionally, the advent of 3D printing technology has revolutionized the production of orthodontic brackets. With 3D printing, orthodontists can now produce brackets on-demand in their clinics, allowing for rapid prototyping and adjustments. This capability is particularly beneficial for cases requiring unique bracket shapes or sizes that are not readily available on the market. Furthermore, 3D printed brackets can be made from a variety of materials, including polymers and composites, which are lighter and cause less irritation to the surrounding oral tissues than traditional metal brackets (11).

The implementation of micro-laser sintering technology in the fabrication of metal brackets represents another technological advancement. This technique involves the use of high-powered lasers to fuse fine particles of metal into a dense, homogenous structure that offers superior strength and reduced weight. The precision of laser sintering allows for the creation of brackets with intricate features and fine details, which are impossible to achieve with conventional casting methods. This results in

brackets that are not only stronger but also more delicate in appearance, appealing to patients who prioritize aesthetics (12). These technological enhancements in bracket design not only push the boundaries of what's possible in orthodontic treatment but also significantly improve the efficiency and comfort of the treatment process. By leveraging these advanced technologies, orthodontists can provide personalized, efficient, and aesthetically pleasing solutions to their patients.

Clinical Outcomes and Patient Comfort with New Materials

The advancements in orthodontic materials have not only targeted improvements in the mechanical properties and aesthetics of devices but also aimed to enhance clinical outcomes and patient comfort. The development of new materials for wires and brackets has significantly influenced the way orthodontic treatment is perceived and experienced by patients. One of the major advancements in this area has been the introduction of softer and more flexible wire materials, such as beta-titanium and newer formulations of nickel-titanium alloys. These materials exert lighter and more continuous forces compared to traditional stainless steel, leading to less discomfort during treatment and potentially shorter treatment times. Clinical studies have shown that these softer materials can reduce the incidence of root resorption and other adverse effects associated with high-force orthodontic treatments, thereby improving the safety and comfort of the orthodontic process (13). Furthermore, the use of innovative bracket materials like ceramic and polymer composites has significantly improved patient satisfaction, particularly in terms of aesthetics. These materials are designed to blend seamlessly with the natural color of teeth, making the orthodontic appliances less noticeable. Additionally, these brackets are often smoother and more rounded, reducing irritation to the inner lips and cheeks, which is a common complaint with traditional metal brackets (14).

Another significant advancement in patient comfort comes from the integration of digital technology in treatment planning. Digital scanning and virtual simulations allow orthodontists to predict treatment outcomes with greater accuracy and plan adjustments more precisely. This not only enhances the effectiveness of the treatment but also reduces the number of visits and adjustments needed, which is a major convenience for patients. Moreover, being able to visualize potential treatment outcomes upfront increases patient engagement and satisfaction with the treatment process (15). These material and technological innovations in orthodontics have thus been instrumental in improving both the clinical outcomes and the comfort levels of patients undergoing orthodontic treatment. The ongoing research and development in this field promises even further enhancements, with a strong focus on patient-centered care and technological integration.

Conclusion

The field of orthodontics has seen substantial advancements in the materials and technologies used for wires and brackets, leading to enhanced clinical outcomes and greater patient comfort. These innovations not only streamline the treatment process but also cater to the aesthetic and comfort needs of patients. Continued research and technological development are essential to further refine these materials and approaches, ensuring optimal results in orthodontic treatments.

References

1. Kusy RP. The future of orthodontic materials: the long-term view. American journal of orthodontics and dentofacial orthopedics. 1998 Jan 1;113(1):91-5.
2. Mantovani D. Shape memory alloys: Properties and biomedical applications. Jom. 2000 Oct;52:36-44.
3. Kakadiya A, Tandon R, Azam A, Kulshrestha R, Bhardwaj M. Recent advancements in orthodontic brackets-a review. Indian Journal of Orthodontics and Dentofacial Research. 2017 Jul;3(3):129-35.
4. Kusy RP. Ongoing innovations in biomechanics and materials for the new millennium. The Angle Orthodontist. 2000 Oct 1;70(5):366-76.

5. Castro SM, Ponces MJ, Lopes JD, Vasconcelos M, Pollmann MC. Orthodontic wires and its corrosion—The specific case of stainless steel and beta-titanium. Journal of Dental Sciences. 2015 Mar 1;10(1):1-7.
6. Birnie D. Ceramic brackets. British Journal of Orthodontics. 1990 Feb 1;17(1):71-5.
7. Kapila S, Sachdeva R. Mechanical properties and clinical applications of orthodontic wires. American Journal of Orthodontics and Dentofacial Orthopedics. 1989 Aug 1;96(2):100-9.
8. Eliades T, Zinelis S, Bourauel C, Eliades G. Manufacturing of orthodontic brackets: a review of metallurgical perspectives and applications. Recent Patents on Materials Science. 2008 Jun 1;1(2):135-9.
9. Birnie D. Ceramic brackets. British Journal of Orthodontics. 1990 Feb 1;17(1):71-5.
10. Cunningham SJ, Jones SP, Hodges SJ, Horrocks EN, Hunt NP, Moseley HC, Noar JH. Advances in orthodontics. Primary Dental Care. 2002 Jan(1):5-8.
11. Bartkowiak T, Walkowiak-Śliziuk A. 3D printing technology in orthodontics–review of current applications. Journal of Stomatology. 2018;71(4):356-64.
12. Dadoo A, Jain S, Mowar A, Bansal V, Trivedi A. 3D printing using CAD technology or 3D scanners, a paradigm shift in dentistry—a review. Int. J. Med. Dent. Res. 2021;1:35-40.
13. Weltman B, Vig KW, Fields HW, Shanker S, Kaizar EE. Root resorption associated with orthodontic tooth movement: a systematic review. American journal of orthodontics and dentofacial orthopedics. 2010 Apr 1;137(4):462-76.
14. Anhoury P, Nathanson D, Hughes CV, Socransky S, Feres M, Chou LL. Microbial profile on metallic and ceramic bracket materials. The Angle Orthodontist. 2002 Aug 1;72(4):338-43.
15. Tarraf NE, Ali DM. Present and the future of digital orthodontics☆. InSeminars in Orthodontics 2018 Dec 1 (Vol. 24, No. 4, pp. 376-385). WB Saunders.