

Fixed Orthodontic Mechanotherapy Beyond MBT: A Review from Origins to Future Perspectives

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Abstract: Fixed orthodontic mechanotherapy has become a cornerstone in achieving predictable tooth movement and functional occlusion. The MBT system, although widely adopted, presents limitations due to its standardized bracket prescriptions that may not accommodate individual anatomical variations. Challenges such as incomplete torque expression, reliance on precise bracket placement, and increased friction with conventional ligatures often necessitate additional adjustments, thereby extending treatment time and compromising efficiency. These drawbacks have driven the exploration of alternative strategies that extend beyond MBT. Contemporary approaches emphasize reduced friction mechanics, digital customization, and patient-centered treatment planning. Advances in computer-aided design and manufacturing enable custom brackets and archwires tailored to specific tooth morphology, while integration of three-dimensional imaging improves diagnostic accuracy and precision in appliance placement. Innovations such as self-ligating systems, digitally guided workflows, and bioadaptive force concepts are reshaping clinical practice by enhancing comfort, efficiency, and treatment predictability. Looking forward, the incorporation of artificial intelligence, smart materials, and real-time monitoring technologies is expected to further individualize orthodontic care. This review critically evaluates the shortcomings of MBT mechanotherapy and highlights the transition toward innovative, technology-driven systems that promise to redefine fixed orthodontics in the future.

Keywords: Fixed Mechanotherapy; MBT System; Orthodontic Biomechanics; Digital Orthodontics; Customized Appliances; Future Perspectives.

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I. INTRODUCTION

Fixed orthodontic mechanotherapy has long been the foundation of orthodontic treatment, providing predictable tooth movement and stable occlusion. Traditional prescriptions such as MBT were developed to standardize torque, tip, and in-out values, thereby reducing the need for extensive wire bending and improving efficiency. However, these systems rely on a generalized design and cannot always accommodate variations in tooth morphology, skeletal relationships, or arch forms. As a result, clinicians often face challenges such as incomplete expression of planned movements, frictional resistance from conventional ligation, and the need for additional finishing procedures [1,2].

The evolution of mechanotherapy is therefore driven by the necessity for greater precision, customization, and

efficiency. Modern orthodontic practice recognizes that “one size fits all” approaches are insufficient in meeting diverse patient needs. Advances in bracket design, materials science, and biomechanical strategies aim to optimize force delivery while minimizing side effects and treatment duration [3,4]. The introduction of newer bracket materials, such as titanium and zirconia, has further improved dimensional accuracy, mechanical properties, and aesthetics [5,6].

In parallel, the rapid integration of digital technology has transformed orthodontics into a more individualized discipline. Three-dimensional imaging, computer-aided design, and digital workflows enable highly accurate bracket positioning, virtual simulations, and customized appliance fabrication. These innovations allow clinicians to plan with greater precision and adapt treatment mechanics to each patient’s specific requirements [7]. Beyond hardware,

artificial intelligence is becoming a central tool in orthodontics, assisting in diagnosis, cephalometric landmark detection, and treatment outcome prediction. AI-driven systems provide enhanced efficiency and consistency, supporting clinicians in decision-making and enabling more personalized care [1,8].

The purpose of exploring mechanotherapies beyond MBT lies in bridging the gap between traditional prescriptions and the demands of modern orthodontic care. By incorporating digital orthodontics, advanced biomaterials, and AI-assisted planning, current and future mechanotherapeutic approaches aim to achieve not only improved treatment accuracy but also enhanced patient experience. This review critically discusses the limitations of MBT, the rationale behind evolving treatment strategies, and the role of digital and technological innovations in shaping the future of fixed orthodontics.

II. HISTORICAL ORIGINS

The origins of fixed orthodontic mechanotherapy can be traced to the development of the edgewise appliance, which provided orthodontists with the first reliable system for controlled tooth movement using rectangular archwires. Although this innovation allowed precise three-dimensional control of teeth, it required extensive wire bending to achieve individualized positioning, making treatment complex and time-consuming [9].

In response to these challenges, the straight-wire appliance was introduced to reduce dependence on intricate wire adjustments. By incorporating torque, angulation, and in-out values into the brackets themselves, it enabled a more standardized approach and simplified mechanics. This transition marked a significant milestone in orthodontics, laying the foundation for pre-adjusted edgewise prescriptions [10].

Among these prescriptions, the McLaughlin-Bennett-Trevisi (MBT) system gained prominence for its systematic incorporation of biological principles and biomechanics into bracket design. The MBT philosophy emphasized optimal torque expression, arch coordination, and controlled force application, which contributed to improved efficiency and consistency in treatment outcomes [11]. It quickly became one of the most widely adopted fixed mechanotherapy systems worldwide.

Despite these advances, standardized prescriptions such as MBT face inherent limitations. Variations in tooth morphology, skeletal patterns, and arch forms often result in incomplete expression of planned movements. This necessitates bracket repositioning, archwire customization, and reliance on finishing procedures. Moreover, the assumption that a single prescription can universally apply to diverse patient populations has been increasingly questioned [12].

These drawbacks prompted the exploration of new mechanotherapies beyond MBT, focusing on precision,

customization, and patient-specific care. Advances in bracket design, digital workflows, and computer-aided customization allow for appliances tailored to individual anatomical and biomechanical requirements. Emerging technologies, such as three-dimensional imaging, CAD/CAM fabrication, and AI-assisted planning, represent the latest phase in the evolution of fixed mechanotherapy [13].

Thus, the historical trajectory of orthodontic appliances reflects a steady progression from generalized mechanical control to increasingly individualized systems. While MBT remains a cornerstone in orthodontic education and practice, the need for improved accuracy, efficiency, and adaptability continues to drive innovation in fixed mechanotherapy.

III. MBT SYSTEM AND ITS IMPACT

The introduction of the McLaughlin-Bennett-Trevisi (MBT) system represented a major step forward in fixed orthodontic mechanotherapy. Designed as a refinement of the straight-wire appliance, MBT integrated principles of biomechanics and biology into a systematic treatment approach. By adjusting torque, tip, and in-out values based on clinical observations, MBT sought to improve efficiency, reduce the need for wire bending, and achieve more predictable treatment outcomes [14].

One of the hallmarks of the MBT philosophy is its emphasis on torque control. By selecting bracket prescriptions tailored to different tooth groups, clinicians could achieve improved incisor inclination and better occlusal relationships. In addition, the system promoted careful space management, incorporation of anchorage strategies, and the use of progressive archwire sequences, all of which contributed to a more standardized and reproducible approach to treatment [15].

The impact of MBT was quickly felt in clinical practice and orthodontic education. Its structured mechanics reduced treatment variability and provided practitioners with a reliable framework for planning and executing cases. Numerous studies demonstrated its utility in managing crowding, controlling overbite and overjet, and achieving balanced occlusion. The widespread adoption of MBT also facilitated communication among orthodontists, as treatment protocols became more uniform [16].

However, limitations of the system became evident with time. Like other pre-adjusted appliances, MBT relies on generalized prescriptions that may not fully account for individual variations in tooth morphology, skeletal discrepancy, or soft tissue profile. This often necessitates bracket repositioning, wire adjustments, and finishing procedures to meet specific treatment goals [17]. Furthermore, as patient expectations increased and digital technology entered orthodontics, the need for more personalized treatment planning revealed the constraints of a universal prescription.

Despite these drawbacks, the MBT system's contribution to orthodontics is significant. It provided a robust

and biologically sound framework that advanced the field beyond the early straight-wire appliance. More importantly, MBT established the foundation upon which newer, digitally guided, and customized mechanotherapies are now being built. Its legacy continues to influence both academic teaching and clinical decision-making, even as the specialty evolves toward individualized, technology-driven orthodontics [18].

IV. BEYOND MBT: TECHNIQUES AND DRAWBACKS

Although the MBT philosophy represented a significant advance in standardization, its reliance on average torque and angulation values, coupled with sensitivity to bracket placement, revealed several shortcomings in complex and individualized cases. In response, orthodontics has seen the development of numerous mechanotherapy systems that attempt to combine precision, efficiency, and esthetics with digital and biomechanical innovation.

The Damon Prescription System popularized passive self-ligation, emphasizing lighter forces and reduced friction at the bracket–wire interface. It is widely applied in crowding and arch development cases, where advocates highlight improved comfort and fewer extractions. Yet, critics note that much of the expansion is dentoalveolar rather than skeletal, and reductions in treatment time are not consistently supported by evidence [19].

SmartClip and Clarity Advanced Brackets from 3M combine self-ligating technology with esthetic ceramic materials. These brackets use nickel-titanium clips instead of ligatures, simplifying wire insertion while improving appearance through translucent ceramics. They are often selected for esthetically conscious patients but present drawbacks such as higher bracket profiles, ceramic brittleness, and increased treatment costs [20].

Incognito Lingual Braces introduced the era of fully customized lingual appliances, fabricated using CAD/CAM technology for each patient. The system offers nearly invisible treatment and high precision, making it popular among adults. However, its limitations include high laboratory costs, prolonged chairside time, initial speech issues, and the steep learning curve for clinicians [21].

The SureSmile Prescription integrates CBCT and intraoral scanning to create a 3D virtual setup, from which robotically bent archwires are fabricated. This improves finishing accuracy and reduces the need for wire adjustments, with studies suggesting shorter treatment times compared to conventional mechanics. Nonetheless, the high cost of digital infrastructure and dependence on specialized training restrict its universal use [22].

The Forestadent BioQuick Self-Ligating System features a low-profile design with a sliding clip mechanism intended to enhance comfort and minimize plaque accumulation. Its flat bracket profile appeals to patients concerned with hygiene and comfort. However, questions remain about the long-term durability of the clip and whether clinical efficiency is

significantly improved compared with conventional brackets [23].

The Insignia Custom Prescription employs digital setups to produce patient-specific brackets and indirect bonding jigs. By tailoring appliance design to the individual dentition, it enhances finishing and reduces detailing requirements. Yet, this approach is costly, technique-sensitive, and requires close collaboration with laboratories [24].

The Harmony Lingual System advanced lingual orthodontics by combining CAD/CAM customization with self-ligating technology. It provided an esthetic alternative that also sought to reduce chairside time compared with earlier lingual systems. Despite these advantages, technical complexity, patient discomfort during adaptation, and higher treatment costs continue to be concerns [25].

The Pitts21 Prescription represents a newer generation of passive self-ligating systems, using a square-slot design to improve torque expression earlier in treatment. This approach has been promoted for enhancing anterior control and improving overall efficiency. While biomechanical rationale is strong, most supporting data remain from bench-top studies and early clinical reports, leaving a need for robust randomized evidence [26].

The Butterfly Prescription System incorporates modified torque and angulation values designed to improve anterior control and anchorage, especially in extraction cases. By attempting to refine biomechanical outcomes beyond MBT, it offers a more individualized prescription. However, published literature remains sparse, and clinical success depends heavily on precision during bracket placement [27].

The H4 Prescription from OC Orthodontics refines self-ligation mechanics with a redesigned clip aimed at reducing friction and improving efficiency. Although system-specific clinical trials are limited, evidence from passive self-ligating bracket studies suggests comparable torque expression and efficiency relative to conventional appliances. Its main limitations are the lack of high-quality trials and uncertainty about significant clinical advantages over other self-ligating systems [28].

The Carriere SLX Prescription integrates low-profile self-ligating brackets into the Carriere Motion philosophy, particularly for Class II and III corrections. These brackets aim to improve sagittal control and treatment efficiency when combined with sagittal correctors. Yet, their benefits are closely tied to patient compliance with elastics, and cost considerations remain barriers to widespread adoption [29].

The Alias Lingual Brackets (Ormco) extended passive self-ligation into lingual therapy, aiming to combine the esthetics of lingual appliances with the efficiency of self-ligation. Early clinical reports suggest improved efficiency compared with earlier lingual designs. However, difficulties in bonding and limited long-term evidence restrict their broader use [30].

Finally, the Bravo Lingual System exemplifies the trend toward fully customized lingual appliances produced with CAD/CAM workflows. It allows for improved lingual adaptation and precision through robotically bent archwires and individualized bracket bases. Despite these advantages, system-specific literature is scarce, and many clinical outcomes are extrapolated from general lingual orthodontics research. High costs and technical demands remain its most significant drawbacks [31].

V. RECENT ADVANCES

The evolution of fixed mechanotherapy beyond MBT has been accelerated by rapid developments in materials science, digital workflows, and computational technologies. Contemporary orthodontics increasingly relies on innovations that enhance diagnostic accuracy, treatment efficiency, and patient-centred care.

Advances in bracket design have focused on improving aesthetics and biomechanics. Ceramic brackets, self-ligating systems, and hybrid materials have been refined to optimize strength, reduce friction, and improve patient acceptance. Despite improvements, concerns regarding brittleness, cost, and torque expression remain significant considerations [32].

The advent of digital orthodontics has transformed clinical practice. High-resolution intraoral scanners and digital models provide accurate, reproducible measurements and facilitate virtual treatment simulations. These technologies not only improve diagnostic precision but also increase patient satisfaction and reduce chairside time [33]. Integration with CAD/CAM systems allows for fully customized brackets and archwires, supporting greater efficiency and accuracy in finishing stages [34].

Three-dimensional imaging, particularly cone-beam computed tomography (CBCT), has enhanced visualization of craniofacial structures, enabling detailed assessment of root morphology, airway dimensions, and treatment-associated risks such as root resorption. While CBCT offers significant diagnostic advantages, its higher radiation exposure compared with conventional radiography warrants careful case selection [35].

The most recent frontier involves artificial intelligence (AI) and machine learning applications. AI-driven algorithms are increasingly applied to cephalometric landmark detection, automated treatment planning, and predictive modelling of treatment outcomes. Early reports suggest substantial time savings and accuracy gains, though validation and clinical integration remain ongoing challenges [36].

Collectively, these advances mark a paradigm shift in orthodontics—transitioning from standardized, one-size-fits-all prescriptions toward individualized, digitally integrated, and technology-driven approaches. While challenges of cost, accessibility, and training persist, the trajectory of innovation suggests a strong future for personalized orthodontic care.

VI. FUTURE PERSPECTIVES

Orthodontics is poised to enter an era of unprecedented transformation, driven by the convergence of digital innovation, biomaterials research, and artificial intelligence. Beyond the MBT system and its immediate successors, the next generation of mechanotherapy will likely focus on creating appliances that are not only more efficient but also increasingly personalized and biologically compatible.

One of the most promising directions is the integration of artificial intelligence (AI) and machine learning into diagnosis, treatment planning, and outcome prediction. AI-based algorithms are already capable of automating cephalometric analyses, predicting growth patterns, and simulating treatment results. In the future, AI could enable fully adaptive orthodontic systems in which appliance prescriptions adjust dynamically to patient-specific biology and treatment response, reducing reliance on generalized protocols.

Another emerging frontier lies in biomaterials and nanotechnology. Research into bioactive coatings and nanostructured wires offers the possibility of reducing friction, enhancing force delivery, and improving patient comfort. Smart materials that respond to intraoral conditions—such as temperature or pH—could provide more consistent biomechanical control while minimizing unwanted side effects such as root resorption.

Digital workflows will also continue to redefine orthodontics. The routine use of intraoral scanners, virtual setups, and 3D printing is expected to expand, making fully customized appliances more accessible. As costs of these technologies decrease, their integration may no longer be limited to specialized practices but become standard in everyday orthodontic care. Furthermore, advances in chairside 3D printing may allow same-day appliance fabrication, reduce laboratory delays and enhance patient convenience.

The future also points toward greater emphasis on minimally invasive and patient-centred care. Temporary anchorage devices, aligner-fixed hybrid therapies, and skeletal anchorage-based mechanics will likely continue to complement fixed mechanotherapy, offering solutions tailored to complex malocclusions. Patient expectations for esthetics, comfort, and shorter treatment duration will drive the refinement of lingual systems, esthetic brackets, and hybrid appliance designs.

Equally important are data-driven and outcome-based approaches. The increasing availability of large-scale clinical data sets opens opportunities for evidence-based refinement of prescriptions, ensuring that newer systems are validated not only through laboratory simulations but also through real-world performance. This will be critical in addressing one of the persistent limitations of many novel systems: the lack of high-quality, long-term clinical trials.

VII. CONCLUSION

Fixed mechanotherapy has advanced beyond MBT, reflecting continuous innovation to improve efficiency, precision, and patient comfort. Emerging systems and digital technologies address the shortcomings of earlier approaches while opening new possibilities for individualized care. Understanding these developments enables clinicians to select appliances that best balance biomechanics with patient needs. Although challenges such as cost, accessibility, and validation persist, the overall direction is clearly progressive. The future of orthodontics lies in harmonizing biological principles with modern innovation to achieve predictable, patient-centered outcomes.

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