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EFFECTIVENESS OF MULTILOOP EDGEWISE ARCHWIRE (MEAW) IN THE NON-SURGICAL MANAGEMENT OF SKELETAL CLASS III AND OPEN BITE: A REVIEW OF OCCLUSAL PLANE RECONSTRUCTION AND MANDIBULAR ADAPTATION

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Abstract

Background / Introduction

The non-surgical correction of borderline skeletal Class III malocclusions and severe anterior open bites presents a significant clinical challenge in fixed orthodontics. While orthognathic surgery is the definitive solution for severe craniofacial discrepancies, patient constraints and risks frequently necessitate conservative camouflage alternatives. Traditional straight-wire mechanics often fall short in these scenarios, inducing unwanted dentoalveolar side effects without correcting the underlying vertical or sagittal architecture. The Multiloop Edgewise Archwire (MEAW) technique offers an alternative philosophy, emphasizing three-dimensional control of the dentition and reconstruction of the functional occlusal plane (FOP) to manage complex malocclusions.

Objectives

This review synthesizes historical data and contemporary clinical evidence to evaluate the biomechanical mechanisms, clinical efficacy, and long-term stability of the MEAW appliance in facilitating therapeutic mandibular adaptation and stable non-surgical camouflage.

Methods / Biomechanical Mechanisms

- The MEAW appliance utilizes five independent horizontal boot loops per quadrant to reduce the load-deflection rate to nearly 1/10th of a standard continuous wire, delivering light, continuous, physiologic forces while allowing localized, segmental tooth control. The core mechanism targets "posterior discrepancy"—the structural crowding and mesial tipping of posterior molars

that breaks the curve of Spee into a pathogenic Double Occlusal Plane (DOP). Through progressive second-order tip-back activations (3° to 5°) combined with intermaxillary vertical elastics, the MEAW appliance uprights and relative-intrudes the posterior segment, eliminating the premature vertical fulcrum and leveling the FOP.

Results

Synthesized literature and high-level retrospective data demonstrate that flattening the FOP with MEAW induces significant functional spatial re-orientation of jaw relationships. Mandibularly, unlocking the occlusion allows for favorable condylar adaptation within the glenoid fossa, resulting in a consistent reduction of the SNB angle. Maxillary-wise, flattening the plane alters the local vertical dimension and induces a spatial re-orientation of Point A relative to the Basion-Nasion plane, significantly improving the BaNA angle and soft-tissue profile harmony. Furthermore, by merging the DOP into a cohesive functional unit that matches the neuromuscular vectors of the stomatognathic system, MEAW demonstrates superior long-term retention and minimized relapse rates compared to traditional anterior extrusion methods.

Conclusions / Modern Evolutions

Reconstructing the functional occlusal plane via the MEAW appliance provides an effective, evidence-based modality for non-surgical camouflage. Although traditional MEAW therapy is limited by strict oral hygiene demands and heavy reliance on patient compliance with elastics, modern hybrid protocols integrating Temporary Anchorage Devices (TADs) and advanced, low-modulus materials like GUM Metal successfully mitigate these drawbacks. When guided by precise diagnostic thresholds and Denture Frame Analysis, dynamic occlusal plane alteration serves as a highly stable, functional alternative to invasive surgical intervention.

Keywords: Multiloop Edgewise Archwire (MEAW), Skeletal Class III, Anterior Open Bite, Occlusal Plane Reconstruction, Mandibular Adaptation, Orthodontic Camouflage.

Introduction

The correction of borderline skeletal Class III malocclusions and severe anterior open bites remains as a demanding domain in fixed orthodontics. While orthognathic surgery stands as the definitive solution for severe craniofacial discrepancies, risks, financial constraints, and patient reluctance frequently necessitate non-surgical camouflage alternatives [8]. Traditional straight-wire mechanics often fall short in these scenarios, as they tend to induce unwanted dentoalveolar side effects—such as excessive incisor flaring or unstable anterior extrusion—without addressing the underlying vertical or sagittal architecture [9].

The Multiloop Edgewise Archwire (MEAW) technique, popularized by Dr. Young H. Kim and Dr. Sadao Sato, remains one of the most debated orthodontic mechanotherapies for the non-surgical correction of complex malocclusions. Traditionally, severe skeletal Class II, Class III, and anterior open bite cases were managed through orthognathic surgery. However, the MEAW appliance offers a conservative alternative by emphasizing 3D control of the dentition and the reconstruction of the occlusal plane [10].

The core of the MEAW philosophy lies in the "Sato school of thought," which suggests that malocclusions are not merely skeletal discrepancies but are functional adaptations to the orientation of

the occlusal plane. Despite its clinical success, a significant conflict exists in the literature regarding the nature of the results achieved. Proponents argue for functional skeletal adaptation and mandibular repositioning, while critics maintain that the outcomes are strictly the result of extensive dentoalveolar compensation [11].

The Multiloop Edgewise Archwire (MEAW) appliance remains a cornerstone in "Functional Orthodontics," offering a non-surgical alternative for managing complex malocclusions. This review synthesizes historical data and current clinical evidence to evaluate how MEAW facilitates mandibular adaptation to achieve stable, non-surgical camouflage.

1. Historical Context

The MEAW technique was introduced in **1967** by **Dr. Young H. Kim**, an Orthodontic Professor at Boston University. Originally developed to address the stability challenges of anterior open bites, the technique gained global prominence through the work of **Dr. Sadao Sato** (Kanagawa Dental College, Japan) [10].

Sato expanded the philosophy by integrating craniofacial dynamics, proposing that malocclusions like Class III are often driven by "posterior discrepancy"—the overcrowding or mesial tipping of posterior teeth that shifts the occlusal plane and displaces the mandible [12].

Etiological Principles: The Sato Philosophy

To understand why MEAW is effective, the literature shifts focus from isolated tooth positions to global craniofacial dynamics. Dr. Sadao Sato's "Craniofacial Dynamic Theory" posits that the inclination of the occlusal plane is a primary driver, rather than a symptom, of skeletal malocclusions[12].

The Mechanism of Posterior Discrepancy

A cornerstone of this philosophy is **posterior discrepancy**—the structural mismatch between the available bony arch perimeter in the tuberosity or retromolar pad area and the mesiodistal mass of the erupting permanent molars.

- When space is insufficient, the second and third molars exert a forward pressure vector, leading to the mesial tipping of the entire posterior segment [13].
- This mesial tipping induces a "squeeze-out" effect, leading to over-eruption of the molars and an abrupt alteration in the curve of the arch [5].

The Double Occlusal Plane (DOP) Phenomenon

This localized posterior tipping breaks a singular, continuous curve of Spee into two separate vertical segments, resulting in a **Double Occlusal Plane (DOP)**:

1. **The Anterior Occlusal Plane:** Spanning from incisor to canine.

2. **The Functional Posterior Occlusal Plane:** Spanning from premolar to molar [5].

In an anterior open bite or skeletal Class III presentation, this posterior tipping flattens the posterior FOP. The resulting loss of posterior vertical support creates a "wedging effect" that acts as a premature fulcrum. The mandible responds by rotating clockwise (downward and backward) to worsen an open bite, or it adapts via an anterior functional displacement to worsen a Class III profile [12].

2. Appliance Design and Material Specifications

The MEAW is essentially an ideal edgewise archwire with the addition of **five L-loops** (or "boot loops") per quadrant, starting distal to the lateral incisors. This structural change yields precise physical advantages:

- **Wire Dimensions:** Traditionally fabricated from **0.016x0.022-inch** Stainless Steel (for 0.018 slots) or **0.017x0.025 inch** (for 0.022 slots).
- **Material Alternatives:** In recent years, **GUM Metal** (a super-elastic titanium alloy) has been utilized to reduce patient discomfort while maintaining the necessary stiffness for occlusal plane control.
- **Loop Function:** The loops increase the total length of the wire to approximately 14 inches. This structural change yields precise physical advantages:

 Reduction **in Load-Deflection Rate:**

The forces delivered drop to approximately 1/10th of a standard straight wire, producing continuous, gentle, and biologically optimal forces.

 Independent **Segmental Control:**

Each loop isolates an individual tooth. This allows for localized torque, intrusion, or extrusion without causing reciprocal alignment errors across the rest of the arch [10].

3. Biomechanics and Activation

The core mechanism of MEAW is the **reconstruction of the occlusal plane** through progressive posterior tip-back bends. The MEAW appliance functions as a highly flexible, segmented wire system hidden within a continuous arch

Primary Activations:

- **Tip-Back Bends:** Progressive 3^0 to 5^0 second-order tip-back angulations are placed at the loop bases from the premolars to the last molars to upright the mesially tipped posterior teeth.
- **Step Bends:** Used to selectively extrude or intrude specific teeth by adjusting the horizontal components of the loops.

- **Torque Control:** The rectangular cross-section allows for active or passive torque to maintain or change axial inclinations [10].

The Role of Elastics:

MEAW is rarely used in isolation. **Short vertical elastics** (3/16 or 1/8 inch, typically 6 oz) are crucial to express the archwire's activations. In Class III cases, these elastics prevent the "side effects" of tip-back bends and facilitate the counter-clockwise rotation of the mandible needed to close the bite [16]. In other words, for a Class III camouflage, they act as an anchor, preventing the reciprocal extrusion of maxillary molars during tip-back activation and directing the force vector to flatten the occlusal plane[14].

Mandibular Adaptation and Camouflage Outcomes

The primary clinical objective of altering the FOP via MEAW is to induce therapeutic **mandibular adaptation**. When progressive tip-back activations upright and relative-intrude the posterior teeth, the premature vertical fulcrum is eliminated.

What the Evidence Shows

- **Sagittal Shift:** Landmark retrospective studies comparing MEAW to orthognathic surgery (such as *Tran et al., 2026*) demonstrate that while surgery provides greater skeletal modification, MEAW significantly improves anteroposterior bimaxillary relationships in borderline patients. This occurs through a reduction in the **SNB angle** and positive changes in the **BaNA angle**, driven by condylar adaptation within the glenoid fossa.

- The Role of the BaNA Angle: Evaluated as the angle between Basion-Nasion (Ba-N) and Nasion-Point A (N-A), this parameter serves as a sensitive metric for maxillary protrusion relative to the posterior cranial base. While the absolute basal body of the maxilla may show limited direct bone remodeling without surgery, flattening the functional occlusal plane with MEAW alters the vertical dimension. This induces a spatial re-orientation of Point A relative to the Ba-N plane, effectively improving the profile soft-tissue balance.

- **Vertical Control:** Systematic reviews (e.g., *Tabancis et al., 2020*) confirm that open bites are closed by **posterior molar intrusion and uprighting** rather than anterior tooth extrusion, leading to a stable counter-clockwise autorotation of the mandible [15].

4. Clinical Indications

Literature identifies several scenarios where MEAW outperforms traditional straight-wire mechanics:

1. **Anterior Open Bite:** Historically its primary indication; effective via posterior intrusion and uprighting rather than just anterior extrusion.
2. **Skeletal Class III Camouflage:** Corrects the "posterior discrepancy" to allow for mandibular adaptation without orthognathic surgery.
3. **Vertical Malocclusions:** Managing the cant of the occlusal plane in high-angle or low-angle cases.
4. **TMD Patients:** Used to guide the mandible into a more physiologically compatible position to relieve joint discomfort [10].

5. Advantages and Limitations

Advantages:

- **Stability:** By addressing the axial inclination of posterior teeth and the occlusal plane, it reduces the risk of relapse in open bite cases.
- **Non-Surgical:** Offers a viable alternative for patients who refuse or cannot undergo surgery.
- **Individual Control:** Allows for precise vertical and sagittal control of every tooth [10].

Limitations:

- **Patient Compliance:** Success is entirely dependent on the consistent wear of intermaxillary elastics.
- **Oral Hygiene:** The complex loop design makes cleaning difficult and can increase the risk of decalcification.
- **Clinical Skill:** Requires significant expertise in wire bending and a deep understanding of functional occlusal dynamics [10].

Modern Evolutions: Hybrid MEAW and Material Science

Literature from **2024 to 2026** highlights crucial upgrades that address the traditional limitations of MEAW—namely, heavy reliance on patient compliance and oral hygiene difficulties due to the complex loops.

- **The Hybrid MEAW (TAD Integration):** Modern protocols combine MEAW with **Temporary Anchorage Devices (TADs)** placed in the infrazygomatic crest or mandibular

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buccal shelf. This provides an absolute skeletal anchor to distalize the lower dentition, sharply decreasing the patient's daily elastic wear requirements [17].

- **Transition to Advanced Materials:** The use of **GUM Metal** (a super-elastic, low-modulus titanium-niobium alloy) has gained significant traction. Recent clinical evaluations show that clinicians can achieve identical uprighting forces with simpler **omega loops** or basic vertical offsets, replacing the bulky boot loops to improve patient comfort and oral hygiene [18].

Stability and Long-Term Retention

The superiority of MEAW over straight-wire mechanics regarding long-term retention lies in its respect for functional anatomy. Traditional open bite correction via anterior extrusion leaves the posterior discrepancy unaddressed, resulting in high relapse rates due to posterior muscular fulcruming.

Because MEAW eliminates posterior crowding and blends the Double Occlusal Plane into a single, cohesive functional unit, the neuromuscular feedback loops of the stomatognathic system are stabilized. When the teeth intercuspate along an occlusal plane that matches the functional paths of the masticatory muscles and the TMJ, the risk of post-treatment relapse is drastically minimized [19].

Discussion

The primary objective of this literature review was to evaluate the efficacy of the Multiloop Edgewise Archwire (MEAW) in the non-surgical management of borderline skeletal Class III and anterior open bite malocclusions. The synthesized literature reveals a distinct paradigm shift: while traditional fixed mechanics treat malocclusions through static, localized tooth movement, the MEAW philosophy addresses the vertical and sagittal discrepancy by reconstructing the functional occlusal plane (FOP) to guide macroscopic mandibular adaptation [1,2].

The Core Biomechanical Distinction

The critical failure point of traditional straight-wire mechanics in severe vertical and sagittal discrepancies is its inherent rigidity. When a clinician attempts to level a severe, step-like curve of Spee or correct an anterior open bite using continuous wires, the mechanics distribute forces broadly across the arch. This inevitably results in the round-tripping of teeth, excessive, unstable anterior extrusion, and severe incisor flaring [3].

In contrast, the literature demonstrates that the unique geometry of the MEAW archwire—specifically the inclusion of five independent horizontal boot loops per quadrant—overcomes these limitations

through two distinct physical mechanisms. First, it increases the total wire perimeter, which reduces the load-deflection rate to nearly 1/10th that of a standard continuous wire [3,4]. This provides light, continuous, physiologic forces that are highly favorable for periodontal ligament remodeling. Second, it allows for individual, segmental control over every single tooth unit. A clinician can introduce local activations (torque, intrusion, or extrusion) to a single tooth without creating reciprocal tracking errors across adjacent segments [4].

Decoding Mandibular Repositioning: Dentoalveolar vs. Skeletal Change

A central debate within the literature is whether MEAW achieves true skeletal alteration or merely extensive dentoalveolar camouflage. Groundbreaking retrospective data, most notably the 2026 study by Tran et al., provides clarity using advanced cephalometric modeling. When comparing MEAW therapy to orthognathic surgery in Class III configurations, regression analyses show that while surgery produces direct, profound changes at the basal bone level, MEAW induces an impressive functional re-orientation of the jaw relationships [7].

The sagittal correction observed in the literature is twofold. Mandibularly, progressive second-order tip-back activations (3^0 to 5^0) upright and relative-intrude mesially tipped posterior molars [4,5]. This eliminates the posterior premature contacts and the "wedging effect" caused by posterior discrepancy [2]. Once this interference is removed, the mandible is "unlocked" and allowed to adapt within the glenoid fossa, reflected in a consistent reduction of the SNB angle [7]. Maxillary-wise, the 2026 evidence highlights a statistically significant post-treatment increase in the **BaNA angle** (Ba-N-) [7]. This is highly significant for the discussion: it demonstrates that while the absolute skeletal body of the maxilla may not change biologically, flattening the posterior functional occlusal plane alters the local vertical dimension. This creates a favorable spatial re-orientation of Point A relative to the Basion-Nasion (Ba-N) cranial base plane, directly improving soft-tissue profile harmony without a scalpel [7].

Relapse Mitigation and Functional Stability

The long-term stability of anterior open bite correction remains one of the most notoriously unpredictable challenges in clinical orthodontics. Traditional open bite correction achieved via anterior extrusion exhibits exceptionally high relapse rates. This is because it leaves the underlying posterior discrepancy unaddressed, leading to a mechanical fulcruming effect when the patient bites down—often termed the "watermelon seed" effect.

The literature strongly suggests that MEAW therapy yields superior long-term retention because it targets the root etiology of the open bite [1,5]. By uprighting the posterior segments and merging the pathogenic **Double Occlusal Plane (DOP)** into a single, cohesive line of occlusion, the vertical dimension is stabilized at the back of the mouth. When the teeth intercuspate along an occlusal plane that matches the precise functional vector of the masticatory muscles and the temporary movement of

the TMJ, the neuromuscular feedback loops of the stomatognathic system stabilize, and the structural risk of post-treatment relapse is minimized [5].

Clinical Limitations and the Modern "Hybrid" Landscape

Despite its documented success, the literature notes clear clinical challenges associated with traditional MEAW therapy. The complex loop configuration creates significant structural undercuts, increasing the risk of plaque accumulation, decalcification, and gingival hypertrophy if oral hygiene is not immaculate. Furthermore, the appliance is entirely dependent on excellent patient compliance with short, heavy intermaxillary vertical elastics (3/16-inch, 6 oz); without these elastics to anchor the wire, the tip-back activations would simply cause severe, unwanted reciprocal extrusion of the upper molars [3,4].

To bypass these hurdles, contemporary literature from 2024 to 2026 emphasizes the integration of modern innovations. The advent of **Hybrid MEAW protocols**—where the archwire is supported by Temporary Anchorage Devices (TADs) placed extra-alveolarly in the infrazygomatic crest or mandibular buccal shelf—has revolutionized the technique [6]. TADs provide an absolute, skeletal anchor that completely counteracts the extrusive side effects of the wire, drastically lowering the patient's daily elastic wear requirements. Concurrently, the transition to advanced material sciences, specifically **GUM Metal** (a low-modulus, highly ductile titanium-niobium alloy), allows clinicians to achieve identical distal uprighting forces using simpler omega loops or basic vertical offsets instead of the bulky, traditional boot loops. This evolution directly solves the long-standing hygiene and compliance complaints while fully preserving the underlying biomechanical philosophy of occlusal plane reconstruction.

7. Clinical Implications and Guidelines

The synthesis of contemporary literature on the Multiloop Edgewise Archwire (MEAW) highlights critical guidelines for managing borderline skeletal discrepancies in daily practice:

- **Case Selection and Diagnostic Thresholds:** The success of non-surgical camouflage using MEAW depends entirely on precise case selection. While the technique is highly effective for borderline skeletal Class III and severe anterior open bites, cases presenting with a true, severe structural discrepancy—such as an ANB angle of less than 5^0 or an extremely severe vertical discrepancy—remain within the strict domain of orthognathic surgery. Clinicians must use **Denture Frame Analysis** alongside traditional cephalometrics to measure the exact degree of the **Double Occlusal Plane (DOP)** and quantify the **posterior discrepancy** before beginning treatment [3,5].

- **Chairside Management and Oral Hygiene:** The intricate loop configuration of a traditional MEAW significantly increases the number of plaque retentive areas. To avoid enamel decalcification, white spot lesions, and severe gingival hypertrophy, clinicians must emphasize

immaculate oral hygiene protocols. This includes prescribing chlorhexidine or high-fluoride mouthwashes at every recall.

- **Compliance Engineering with TADs:** To bypass the historical Achilles' heel of the MEAW technique—extreme patient reliance on intermaxillary vertical elastics—practitioners should proactively adopt modern **Hybrid MEAW protocols** [6]. Strategically placing extra-alveolar Temporary Anchorage Devices (TADs) in the mandibular buccal shelf or infrazygomatic crest provides absolute skeletal anchorage. This minimizes the risk of unwanted molar extrusion and drastically reduces the patient's daily elastic-wear burden, ensuring predictable treatment outcomes even in moderately compliant individuals.
- **Material Science Integration:** Moving forward, clinicians should transition away from traditional, bulky Stainless-Steel loops and lean toward modern **GUM Metal** or beta-titanium wires [6]. Utilizing these advanced, low-modulus alloys allows for identical tip-back activations and vertical control using simple omega loops or basic offsets. This maintains the core mechanics of occlusal plane reconstruction while vastly increasing patient comfort and simplifying chairside adjustments.

8. Conclusion

Reconstructing the functional occlusal plane via the Multiloop Edgewise Archwire appliance provides an effective, highly scientific, and evidence-based modality for the non-surgical camouflage of borderline skeletal Class III and anterior open bite malocclusions. By resolving posterior discrepancy and unifying the pathogenic double occlusal plane into a single, balanced line of occlusion, the technique effectively eliminates posterior dental interferences. This collapses the premature vertical fulcrum, allowing for favorable, therapeutic **mandibular adaptation** within the glenoid fossa.

Recent high-level evidence from 2026 confirms that while orthognathic surgery remains the gold standard for severe skeletal corrections, MEAW therapy induces a profound spatial re-orientation of jaw relationships. This is highlighted by significant changes in the **BaNA angle** and **SNB angle**, which optimize facial profile aesthetics and soft-tissue balance without a scalpel [7].

While traditional MEAW mechanics carry limitations regarding oral hygiene and a heavy reliance on vertical elastics, modern evolutions—specifically the integration of extra-alveolar TADs and advanced materials like GUM Metal—have successfully modernized the workflow. When guided by strict diagnostic parameters and sound biomechanical principles, dynamic occlusal plane alteration stands as a vital tool in modern orthodontics, offering a highly stable, functional alternative to invasive surgical intervention.

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