COMPARATIVE CHARACTERISTICS OF PROTRACTION FACEMASKS AND MAXILLARY EXPANSION APPLIANCES

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Abstract

Protraction facemasks and maxillary expansion appliances are widely used orthopedic modalities for modifying maxillofacial relationships in growing patients with maxillary deficiency. Their clinical effects vary substantially according to anchorage design, force application, expansion protocol, and the relative contribution of skeletal and dentoalveolar adaptation. Conventional tooth-borne rapid maxillary expansion combined with facemask therapy can produce clinically relevant maxillary advancement but may also be associated with dental compensation and vertical skeletal changes. In contrast, hybrid and skeletal anchorage-supported systems, including hybrid-Hyrax, miniscrew-assisted rapid palatal expansion, and bone-anchored maxillary protraction, have been developed to improve orthopedic force transmission and reduce undesirable dental effects. Alternate rapid maxillary expansion and constriction (Alt-RAMEC) represents an additional biomechanical strategy intended to enhance circummaxillary sutural response. This review compares the principal characteristics of conventional, hybrid, and skeletal anchorage-based protraction and expansion protocols, with emphasis on skeletal effects, vertical control, dentoalveolar changes, airway effects, soft-tissue adaptation, and treatment stability. Understanding these differences is essential for selecting an appliance configuration that corresponds to the patient's skeletal characteristics and treatment objectives.

Keywords: protraction facemask; maxillary expansion; rapid maxillary expansion; hybrid Hyrax; MARPE; skeletal anchorage; Alt-RAMEC; orthodontic biomechanics.

Introduction

Protraction facemasks and maxillary expansion appliances represent two major categories of orthopedic appliances used to modify maxillofacial skeletal relationships during growth. Although they may be used as independent modalities, their combination has been extensively investigated because transverse expansion can modify the mechanical environment of the maxillary complex and may facilitate subsequent orthopedic protraction.[1–3]

The clinical response to these appliances is strongly influenced by the anchorage system. Conventional tooth-borne appliances transmit orthopedic forces primarily through the dentition, whereas hybrid and skeletal anchorage systems transfer a greater proportion of the applied load directly to skeletal structures.[4,6–8] Consequently, different appliance configurations may produce substantially different skeletal, dentoalveolar, and vertical responses.

Biomechanical Characteristics of Protraction Facemasks

Protraction facemasks generate anteriorly directed orthopedic forces through elastics connected between an extraoral framework and an intraoral anchorage appliance. Common clinical configurations apply approximately 300–500 g of force per side, with the force vector typically directed 15°–30° downward relative to the occlusal plane.[2,3,5,6]

The biomechanical response depends not only on force magnitude but also on the location of the intraoral hooks and the relationship between the applied force vector and the center of resistance of the maxillary complex. Conventional tooth-borne systems may produce a combination of skeletal advancement and dentoalveolar compensation. Reported dental effects include maxillary incisor proclination and molar extrusion, while clockwise mandibular rotation may contribute to an increase in lower anterior facial height.[3,6,7]

Skeletal anchorage systems have been developed to improve control of these effects. Hybrid Hyrax appliances combine skeletal and dental anchorage, while bone-anchored maxillary protraction systems use miniplates or other skeletal anchorage devices to transmit orthopedic forces with less direct loading of the dentition.[4,6,8]

Characteristics of Maxillary Expansion Appliances

Maxillary expansion appliances differ in both design and anchorage. Conventional rapid maxillary expansion (RME) devices, including Hyrax and Haas-type appliances, primarily rely on dental anchorage. Hybrid appliances incorporate miniscrews or other skeletal anchorage components, while miniscrew-assisted rapid palatal expansion systems aim to increase the skeletal component of transverse expansion.

An additional approach is the alternate rapid maxillary expansion and constriction (Alt-RAMEC) protocol. Rather than maintaining expansion alone, Alt-RAMEC alternates expansion and constriction cycles and has been proposed as a method of increasing circummaxillary sutural responsiveness before or during maxillary protraction.[2,4,9,10]

The choice of expansion design therefore influences not only transverse correction but also the way subsequent orthopedic forces are distributed between teeth and skeletal structures.

Comparative Characteristics of Major Appliance Configurations

Appliance configuration	Primary anchorage	Principal biomechanical characteristic	Skeletal response	Potential dentoalveolar effects	Vertical control
Conventional RME + facemask	Tooth-borne	Orthopedic force transmitted predominantly through dentition	Moderate maxillary advancement	Incisor proclination and molar extrusion may occur	Relatively limited
Hybrid Hyrax + facemask	Skeletal + tooth-borne	Combined dental and skeletal force transmission	Greater skeletal contribution than conventional RME in selected protocols	Reduced dental compensation	Improved
MARPE + facemask	Predominantly skeletal	Direct engagement of the maxillary skeletal structures	Increased orthopedic component	Less dental tipping	Improved
Bone-anchored maxillary protraction (BAMP)	Skeletal/miniplate	Direct skeletal traction	Strong orthopedic effect with reduced dental loading	Minimal unwanted dental movement	Favorable
Alt-RAMEC + protraction	Tooth-borne or hybrid	Repeated expansion–constriction cycles combined with protraction	May enhance maxillary advancement	Depends strongly on anchorage design	Variable

Comparative clinical evidence indicates that skeletal and hybrid anchorage configurations can provide greater control of dentoalveolar side effects than conventional tooth-borne systems.[3,4,7,8,11–14] However, the magnitude of skeletal advancement varies among studies and should not be attributed solely to the anchorage system because treatment age, skeletal maturation, force magnitude, treatment duration, and individual growth pattern also influence outcomes.[1,3,8]

Skeletal and Dentoalveolar Differences

One of the principal distinctions between conventional and skeletal anchorage systems is the relative proportion of skeletal versus dental response.

Conventional RME combined with facemask therapy can produce measurable maxillary advancement, but part of the clinical correction may arise from dental compensation.[3,6,7] In particular, maxillary incisor proclination and molar extrusion can accompany treatment and may contribute to changes in mandibular rotation and lower facial height.

Hybrid Hyrax and miniscrew-supported systems are designed to reduce these effects by transferring a larger proportion of the orthopedic load to skeletal anchorage.[4,7,8,11,12]

Comparative investigations have reported improved vertical control and reduced dental tipping with skeletal anchorage-based protocols.

Bone-anchored maxillary protraction represents the most direct approach to skeletal force transmission among the systems considered. By using miniplates, orthopedic traction can be applied with limited dependence on the dentition.[6],[13],[14] Nevertheless, these systems require surgical placement and subsequent management of the anchorage devices, representing an important clinical trade-off.

Airway and Soft-Tissue Characteristics

Expansion and protraction protocols may also affect upper airway dimensions and facial soft tissues. Studies comparing different maxillary protraction protocols have reported changes in pharyngeal airway dimensions following orthopedic treatment, although the magnitude and clinical significance of these changes vary according to the appliance and treatment protocol.[2],[16]

Soft-tissue adaptation is another important consideration. Clinical studies have demonstrated changes in the facial soft-tissue profile following skeletal expansion and maxillary protraction, including changes in upper-lip position.[5],[6] Such changes reflect the underlying skeletal and dental modifications and should therefore be interpreted together with hard-tissue measurements.

Treatment Timing and Stability

The orthopedic response to maxillary protraction and expansion is strongly associated with growth stage. Earlier intervention generally provides greater potential for skeletal modification because the craniofacial complex remains actively developing.[1],[15],[18]

However, treatment timing alone does not determine the final result. Skeletal maturity, initial severity of maxillary deficiency, mandibular growth pattern, appliance design, patient compliance, and treatment duration all contribute to treatment response.[1],[3],[15]

Long-term studies indicate that some of the initial sagittal skeletal changes may diminish over time as a consequence of continued craniofacial growth.[1],[15] Therefore, evaluation of treatment effectiveness should ideally include both short-term skeletal and dentoalveolar changes and longer-term stability.

Clinical Implications

The comparative characteristics of these appliances suggest that there is no universally optimal configuration for every patient. Conventional tooth-borne RME and facemask therapy remains technically straightforward and clinically accessible. Hybrid systems provide an intermediate approach by combining skeletal and dental anchorage, while fully skeletal systems may provide greater control over orthopedic force transmission.

The selection of an appliance should therefore consider:

1. the patient's skeletal maturity;
2. transverse maxillary dimensions;
3. sagittal skeletal relationships;
4. vertical facial pattern;
5. anchorage requirements;
6. anticipated dentoalveolar compensation;
7. patient compliance;
8. surgical tolerance and anatomical limitations; and

9. long-term stability objectives.

Conclusion

Protraction facemasks and maxillary expansion appliances differ substantially in their anchorage requirements, biomechanical force transmission, skeletal effects, dentoalveolar side effects, and vertical control. Conventional tooth-borne RME with facemask therapy provides an established and relatively simple approach but may be associated with greater dental compensation. Hybrid Hyrax and miniscrew-assisted systems increase skeletal anchorage and may improve control of unwanted dental and vertical effects. Bone-anchored maxillary protraction provides the most direct skeletal force pathway but requires surgical anchorage and additional clinical management. Alt-RAMEC represents a protocol-level modification that may enhance orthopedic response when appropriately combined with protraction. Overall, appliance selection should be individualized according to skeletal maturity, craniofacial morphology, anchorage requirements, and treatment objectives rather than based on a single standardized protocol.

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