

DENTAL BITES

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ORTHODONTIC AND ORTHOGNATHIC



a quarterly publication of



KMCT
DENTAL COLLEGE



KMCT Medical College Campus, Mukkom, Kozhikode - 673 602

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INNOVATION AND
ENTREPRENEURSHIP
DEVELOPMENT CENTRE



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Editorial

Dear Readers,

Advancing Smiles with Technology: KMCT Dental College's Commitment to Excellence

It is with great pride and enthusiasm that I pen this editorial for our esteemed KMCT Dental College journal, focusing on the dynamic and transformative fields of orthodontics and orthognathic surgery. As we continue to uphold our commitment to academic and clinical excellence, we also embrace the latest advancements in technology to revolutionize patient care and education.

At KMCT Dental College, we have always believed in staying at the forefront of dental and medical innovation. The collaborative efforts of the Department of Oral and Maxillofacial Surgery and the Department of Orthodontics have been instrumental in achieving remarkable milestones. Utilizing cutting-edge technology and adhering to global best practices, the teams have successfully managed a significant number of complex dentofacial deformity cases with excellent outcomes. This synergy between the departments stands as a testament to the importance of teamwork and interdisciplinary approaches in modern dentistry .

We have integrated cutting-edge technologies such as Virtual Surgical Planning (VSP) and 3D printing into the diagnosis and management of dentofacial deformities. These advancements have redefined how we approach complex cases, enabling precise treatment planning, enhanced predictability, and superior patient satisfaction.

Virtual Surgical Planning allows us to visualize and simulate surgical outcomes with unparalleled accuracy, ensuring that each procedure is meticulously planned and executed. This technology not only minimizes surgical risks but also provides our patients with a clear understanding of their treatment journey. Similarly, 3D printing has revolutionized the creation of customized surgical cutting guides, Patient specific implants, orthodontic aligners and anatomical models, significantly enhancing efficiency and precision in our clinical workflows.

As we continue to adopt these transformative technologies, we also strive to cultivate a learning environment where our students and faculty are equipped to lead the future of dentistry. Through research, hands-on training, and interdisciplinary collaboration, KMCT Dental College remains dedicated to producing professionals who are not only skilled clinicians but also pioneers in adopting innovations for the betterment of patient.

With warm regards,

Dr Manoj Kumar K.P
Principal



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Review Article

Approaches to Mandibular condyle, Surgical and Clinical insights

*Abdulla Noor M, **Manoj Kumar KP, ***Jaslin PA, *Anu Kalapurakal, *Salsabeel Abdul Akbar

Abstract

The mandibular condyle plays a vital role in mandibular movement, and its dysfunction or fractures can lead to significant clinical issues. Over the years, various approaches to the mandibular condyle have been developed for both diagnostic and therapeutic purposes. These approaches are employed for surgical intervention, such as in cases of fractures, TMJ disorders, or other pathologies, and for understanding the biomechanics and morphology of the joint.

Surgical techniques include both open and closed approaches, with the open surgical approach being further categorized into extraoral and intraoral techniques. Extraoral techniques provide better access to the condyle but come with the potential for more visible scars, whereas intraoral techniques are preferred for minimizing scarring but can present challenges in terms of visibility and access. Additionally, advancements in minimally invasive surgery and endoscopic procedures are reshaping how condylar pathologies are treated, offering the benefits of reduced recovery times and minimized patient morbidity.

Overall, the choice of approach to the mandibular condyle depends on various factors, including the type of pathology, the patient's condition, and the desired outcome. Ongoing advancements in surgical techniques and diagnostic technologies continue to improve management strategies, with an emphasis on preserving function and minimizing complications.

Key words: *mandibular condyle, temporomandibular joint, preauricular, retromandibular, transoral approaches*

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Introduction

The mandibular condyle is a critical structure in the temporomandibular joint (TMJ), playing a pivotal role in the movement and function of the jaw. This bony prominence articulates with the glenoid fossa of the temporal bone, enabling various movements such as opening, closing, and lateral excursions of the jaw. Fractures of the mandibular condyle account for 25–50% of all mandibular fractures.^{1,2} Due to its importance in facial anatomy and function, the mandibular condyle is often a site of interest in oral and maxillofacial surgery, particularly in the management of fractures, deformities, or disorders that affect the temporomandibular joint. If left untreated, they can lead to ankylosis of the temporomandibular joint (TMJ), malfunction of the joint, occlusal disorders, or mandibular deviation.³ This article explores the different approaches to the mandibular condyle, focusing on surgical access, techniques and clinical considerations

Anatomy of the condyle

Before discussing the surgical approaches, it is essential to understand the anatomy of the mandibular condyle. The mandibular condyle (or the head of mandible) is the upper part of the condylar process of mandible. It is crucial for the

jaw's movement in the temporomandibular joint (TMJ). This joint is divided into upper and lower sections by a fibrous articular disc. The mandibular condyle articulates with this disc to enable the jaw to open and close like a hinge in the joint's lower section. In the upper section, both the articular disc and the mandibular condyle slide forward or backward. Moving forward, the mandibular condyle and the disc fit under a part of the temporal bone called the articular tubercle; while moving back, they return to their original position in the mandibular fossa of the temporal bone.⁴

Below the mandibular condyle is its neck. The TMJ's fibrous capsule completely surrounds the mandibular condyle and attaches around the neck of the condylar process, securing everything in place.⁵

Indications for surgical intervention

Surgical intervention may be required in cases involving:

- **Fractures of the mandibular condyle:** These fractures can result from trauma, such as motor vehicle accidents or falls. Displaced fractures may require surgical intervention to realign the bone properly.

- **TMJ disorders:** In some instances, surgery is necessary to address dysfunctional joint movements, pain, or conditions like ankylosis.
- **Mandibular deformities:** Abnormal growth or development of the condyle can lead to facial asymmetry, which may necessitate correction through surgical procedures.
- **Occlusion:** In order to correct the proper occlusal function. According to Ellis and Throckmorton, the occlusion is restored by neuromuscular, skeletal, and dental adaptations after closed treatment.⁷ This results in a decrease in the vertical dimension and gives the mandible a retruded appearance.
- **Arthritis or other degenerative conditions:** Some conditions affecting the condyle or TMJ may require surgical treatment to alleviate pain and restore function.

Discussion

A review article by Zachariades et al. in 466 patients with condylar fractures concluded that early mobilisation is essential for the recovery of function to the joint, and this can be provided only by open reduction and internal rigid fixation.⁸

Surgical approaches to the mandibular condyle

Several surgical approaches can be employed depending on the clinical scenario. These approaches differ in terms of incision sites, tissue dissection, and the degree of invasiveness required. Various approaches which exist in the literature that provide accessibility of condyle are preauricular, postauricular, endaural, retromandibular, submandibular, rhytidectomy and the latest intraoral endoscopic approaches.

a. Preauricular Approach

- For many years, the preauricular technique has been the standard for reaching the condyle. It has undergone continuous modification to improve access and visualisation while still safeguarding the facial nerve branches. The Rowe (1972) modification and the Alkayat and Bramley (1979) modification are the most well-liked and currently utilised modifications of the preauricular method. The plate fixation is technically challenging because of the exceedingly small area of ramal exposure, which also shields facial nerve branches and

offers good access to the condylar process.¹⁶

- **Incision:** The preauricular approach is an incision placed anterior to the ear, commonly used for TMJ surgeries, including joint replacement or arthroplasty, as well as for fractures of the condylar neck. The incision is made along the natural skin crease and the dissection proceeds to the condyle(Figure 1).

Fig 1: Preauricular approach



- **Advantages:** This approach offers excellent exposure to the entire TMJ and condyle and is often employed when surgical management of the joint itself is required (e.g., total joint replacement, management of ankylosis).

- **Disadvantages:** While the preauricular approach provides good visualization, it does leave a visible scar, which might be a concern for some patients.

Preauricular incision is not a practical alternative for treating sub condylar fractures.

After a preauricular incision, the incidence of injury to the facial nerve varied from 3.2% to 42.9%, according to studies performed by Tang et al. and Hammer et al^{10,11}

b. Retromandibular Approach (Submandibular extension)

The retromandibular approach is one of the most commonly used methods for accessing the mandibular condyle. This approach is particularly useful in the treatment of fractures and some joint pathologies. The retromandibular approach was initially defined by Hinds and Girotti in 1967 and modified as mini retromandibular by Biglioli and Colletti in 2008.¹⁴

- **Incision:** A curved incision is made just behind the ramus of the mandible, typically anterior to the ear and extending into the submandibular region
- The trans-masseteric anterior parotid (TMAP) approach provides

superior access to the fractured condyle, reduces the risk of facial nerve palsy, and prevents the complications associated with parotid gland incision.⁹ It is necessary to make a preauricular incision in the cervicomastoid skin fold that extends downward in a curvilinear form, though any variation in this incision will work. Access to the masseter next to the anteroinferior edge of the parotid gland, immediately below the parotid duct, is made possible by raising the flap in the subdermal fat plane, superficial to the superficial musculoaponeurotic layer, while maintaining the great auricular nerve. Facial nerve branches are easily recognised and avoided on the masseter muscle surface, whether or not loupe magnification⁶. (Figure 2 and 3)

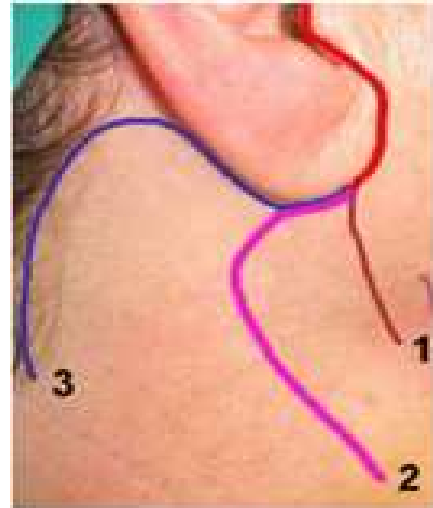


Figure 2: Preauricular skin crease incision with allowable modifications: (1) retromandibular; (2) lazy “S” cervico mastoid; and (3) rhytidectomy.⁶

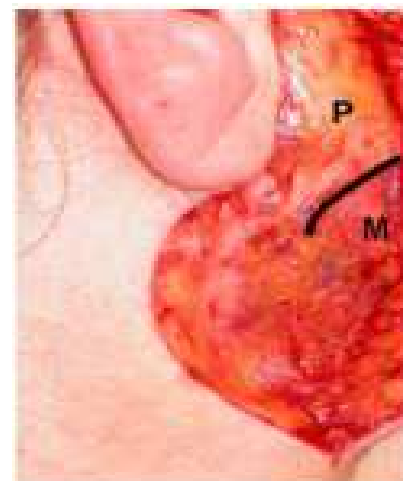


Figure 3: Raised flap showing the anterior edge of the parotid gland and masseter muscle (P: parotid; M: masseter).

Dissection of the sub periosteum along by extending the retromandibular component to the preauricular level, the parotid's anterior boundary is made easier to

maintain. Injury to the temporal and zygomatic branches is prevented by maintaining a shallow dissection in the preauricular region. The high cervical trans masseteric technique for sub condylar fractures was explained by Trost et al.¹³

- In a study by V Gopal Krishnan et al. conducted comparison of different retromandibular approaches; retromandibular trans parotid, retromandibular Antero parotid and retromandibular retro parotid approaches for the management of condyle fractures, and among which retromandibular retro parotid and retro mandibular Antero parotid provide best accessibility with less bleeding and minimal risk of injury to the facial nerve.¹⁵
- **Advantages:** The retromandibular approach provides direct access to the mandibular condyle and its surrounding structures, making it ideal for fractures or conditions involving the posterior aspect of the condyle. It also allows for clear visibility of the condylar head and neck.
- **Disadvantages:** Potential risks include damage to the facial nerve branches (such as the marginal

mandibular branch), which could result in facial asymmetry or paralysis.

c. Transoral Approach

The transoral approach or intraoral approach, involves accessing the mandibular condyle through the mouth.

- **Incision:** An incision is made inside the cheek, along the gingivobuccal sulcus. This technique is typically less invasive than the retromandibular approach ^[18] (Figure 4).

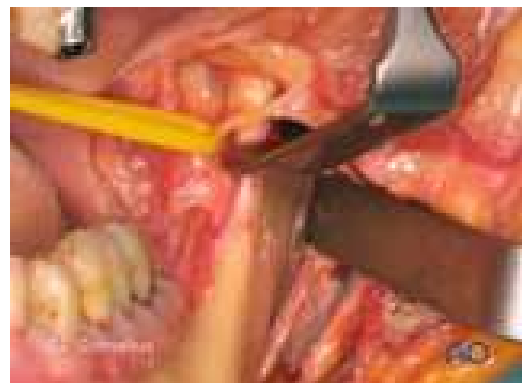


Figure 4: Transoral Approach

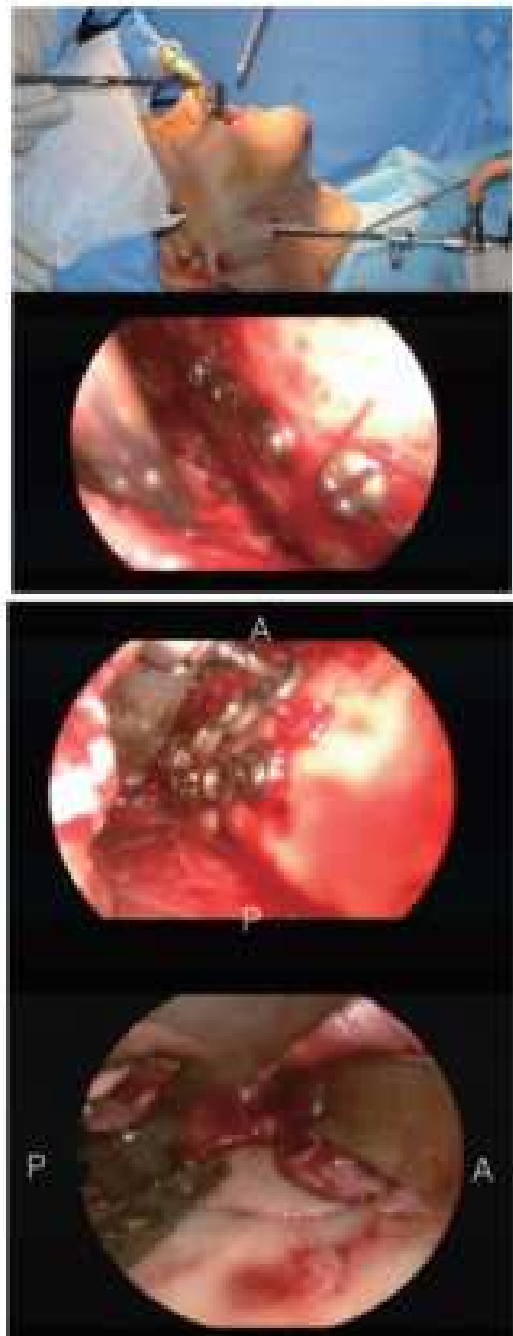
- **Advantages:** The transoral route avoids external scarring, which is often preferable for cosmetic reasons. It is less invasive than other approaches and is typically used for fractures located in the anterior or middle parts of the condyle.

- **Disadvantages:** One of the significant limitations of the transoral approach is limited visibility of the condylar area, particularly when fractures are displaced or complex. In addition, there is a risk of infection, as the surgical field is located in the oral cavity.

d. Endoscopic Approach

- Advancements in minimally invasive surgery have led to the development of endoscopic techniques for accessing the mandibular condyle.
- **Incision:** Small incisions are made near the ear or intraorally, through which an endoscope and surgical instruments are inserted to perform the procedure ¹⁷(Figure 5).

Figure 5: Endoscopic Approach



- **Advantages:** The endoscopic approach is less invasive, with smaller incisions and reduced recovery times. It is particularly effective for certain TMJ surgeries, such as arthroscopic surgery, where

minimal access is needed for joint lavage or minor debridement.

- **Disadvantages:** Limited visualization compared to open approaches and the need for specialized equipment and expertise are some drawbacks of this method.

Postoperative considerations and complications

Following surgery on the mandibular condyle, several considerations must be taken into account to ensure successful outcomes and prevent complications:

- **Pain management:** Adequate postoperative pain control is necessary to ensure comfort and prevent complications related to poor healing or movement restriction.
- **Jaw immobilization:** In some cases, immobilization of the jaw with a splint or bandages may be required to allow for proper healing, especially after fractures.
- **Infection prevention:** As with any surgical procedure, there is a risk of infection, which requires careful wound care and possibly antibiotic prophylaxis.

- **Facial nerve injury:** Careful dissection is critical to avoid damage to the facial nerve, particularly when using the retromandibular approach. Facial nerve palsy can result in cosmetic and functional impairment.

Manisali et al. in 20 patients had condylar process fractures repaired via the retromandibular access route, and 6 patients had facial nerve visualisation throughout the procedure. Following surgery, six individuals experienced temporary atony of the facial nerve, but none of them experienced it permanently.¹²

- **TMJ dysfunction:** In some cases, despite surgical correction, patients may experience long-term TMJ dysfunction or discomfort, which might require further management, including physical therapy or follow-up procedures.

Conclusion

The mandibular condyle is an essential component of facial structure and function, and surgical interventions may be necessary for a variety of conditions affecting it. Choosing the appropriate approach depends on the type of condition,

the location of the problem, and the goals of surgery. Advances in surgical techniques, such as endoscopic and minimally invasive approaches, continue to enhance the precision, safety, and recovery time for patients undergoing procedures on the mandibular condyle. Careful preoperative planning and postoperative care are vital to ensuring optimal outcomes for patients requiring surgical treatment of the mandibular condyle.

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Comparison of three different approaches in treatment of mandibular condylar fractures - Our experience. Natl J Maxillofac Surg. 2023 May-Aug;14(2):256-263.

Digital Orthodontics: An Overview

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Abstract

Digital orthodontics is revolutionizing the way orthodontists diagnose, plan, and execute treatments. The integration of advanced digital technologies, such as 3D imaging, intraoral scanning, computer-aided design and manufacturing (CAD/CAM), and artificial intelligence, has enabled orthodontists to provide more precise, efficient, and personalized care. This article explores the various digital tools and techniques that have transformed orthodontics, including their impact on treatment planning, patient outcomes, and workflow optimization. It highlights the benefits of digital orthodontics, such as improved accuracy, faster treatment times, and enhanced patient satisfaction, while also discussing challenges such as high initial costs, technical learning curves, and data security concerns. Through a review of current technologies and trends, this article aims to provide a comprehensive overview of the state of digital orthodontics today and its future potential in the field of dentistry.

Keywords:*Digital Orthodontics, 3D Imaging, Intraoral Scanners, CAD/CAM Technology, Artificial Intelligence, Orthodontic Treatment Planning, Virtual Models, 3D Printing, Indirect bonding, Aligners, Retainers*

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Introduction

Orthodontics has always been at the forefront of dental innovation, focusing on the diagnosis, prevention, and treatment of dental and facial irregularities. Traditional orthodontic methods have relied on physical impressions, manual adjustments, and limited diagnostic tools. However, with the advent of digital technologies, the orthodontic landscape has undergone a significant transformation. Digital orthodontics integrates various cutting-edge technologies that streamline the orthodontic process, improve precision, and enhance treatment outcomes. The shift to a more digital-driven practice has redefined the way orthodontists approach treatment, offering a higher degree of customization and efficiency in both planning and execution.

The use of digital tools in orthodontics has seen rapid growth, with intraoral scanners, 3D imaging systems, and computer-aided design (CAD) platforms becoming central to modern practices. These innovations offer benefits not only to practitioners but also to patients, improving communication, reducing treatment times, and enhancing the overall patient experience. The introduction of artificial intelligence (AI) and machine learning algorithms into digital orthodontic systems

has further streamlined treatment planning, enabling predictive analytics and more accurate forecasts of treatment outcomes.

This article provides an in-depth overview of digital orthodontics, exploring the technologies that have reshaped the field, the advantages and challenges of their implementation, and the potential future developments that will continue to shape orthodontic care.

Technological Advancements in Digital Orthodontics

1. Intraoral Scanners and 3D Imaging

Intraoral scanners have replaced traditional impressions with a more efficient and accurate process. These handheld devices capture highly detailed digital impressions of the oral cavity, providing 3D models of a patient's teeth and soft tissues. Unlike conventional methods, which involve the use of impression materials that can be uncomfortable and time-consuming, intraoral scanners create a digital representation that is both precise and easy to store for future reference.¹

Moreover, 3D imaging technologies, such as cone beam computed tomography (CBCT), provide high-resolution images of the bone structure and soft tissues,

enabling orthodontists to assess the skeletal relationship of the teeth, the jaw, and surrounding structures. These advanced imaging systems enhance diagnostic capabilities and aid in the development of a more accurate treatment plan. The ability to create virtual 3D models allows for dynamic, real-time adjustments during treatment planning, providing orthodontists with a more holistic view of the patient's needs.

2. CAD/CAM Technology

Computer-aided design (CAD) and computer-aided manufacturing (CAM) are integral components of digital orthodontics. CAD systems allow orthodontists to create customized treatment plans, including the design of aligners, retainers, and appliances. These printers can be used to manufacture indirect bonding trays, surgical guides, orthodontic braces and clear aligners.^{2,3} These methods are better suited than 2D records or solid records since they are easier to physically store, they are prone to less handwriting errors, and they provide a 3D evaluation of craniofacial structures.^{3,4} By using digital models, orthodontists can simulate tooth movement and predict the outcome of the treatment before beginning the process.

CAM technology is employed in the fabrication of orthodontic appliances, including clear aligners, brackets, and wires. The digital workflow ensures that appliances are precisely manufactured according to the specifications of the treatment plan, reducing the likelihood of errors and improving treatment predictability.⁵ The speed and accuracy of CAM technology also streamline the production process, reducing wait times for patients and orthodontists alike.

3. Artificial Intelligence and Predictive Analytics

Artificial intelligence (AI) is increasingly being incorporated into digital orthodontics to enhance decision-making and predict treatment outcomes. AI algorithms can analyze large datasets of patient information to identify patterns and optimize treatment plans. These systems can offer recommendations on the most effective course of treatment, considering factors such as tooth movement, patient age, and individual preferences.⁶

Predictive analytics powered by AI can simulate how teeth will move over time, helping orthodontists anticipate results and modify treatment plans accordingly. By leveraging machine learning, these technologies can continuously improve their recommendations based on real-

world data, offering a more tailored and accurate approach to treatment planning.

4. 3D Printing in Orthodontics

3D printing technology has revolutionized the way orthodontic appliances are fabricated. By using digital models of the patient's teeth, 3D printers can produce customized braces, aligners, and retainers with high precision and speed. This technology allows for the creation of intricate, patient-specific devices that are both functional and comfortable.⁷

3D printing also offers advantages in the creation of trial appliances, such as prototype aligners, which can be used to test the effectiveness of a treatment plan before finalizing the design. This trial phase helps orthodontists make adjustments to the treatment plan based on real-time feedback, enhancing the overall quality and efficiency of the treatment process.

Applications of digital orthodontics in treatment:

I. Indirect bonding

One of the imperative phases of orthodontic treatment is the finishing and detailing phase, which involve a series of steps that essentially begins with ideal

bracket positioning.⁵⁰ years ago Lawrence F. Andrew advocated six keys of normal occlusion and based his straight wire appliance (SWA) to achieve minimal wire bending never the less controlling tooth movement and alignment in three spatial planes through ideal bracket positioning.⁸ Brackets can be positioned clinically either directly with an instrument or indirectly with a transfertray. Indirect bonding (IDB) was first proposed in 1972 Silverman and Cohen.⁹ Previous studies of Aguirre¹⁰, Koo et al¹¹ were consistent with Sabbagh¹², findings in systematic review that indirect bonding as a technique allowed achieving planned bracket positions with high overall accuracy. claims of reduced chair time^{10, 13} were inspected, to truly conclude that chair time is reduced, but on the expense of extra laboratory working time with additional equipment. This overly complex chairside and laboratory phase contributed to minimal percentage of orthodontists that employ indirect bonding as part of their daily practice, with prevalence of only 18% among clinicians. Other advantages included less physical stress and improved productivity of orthodontist as all bracket placement decisions have been previously made in the laboratory.¹¹ The latest advances in digital technology, such as intraoral scanning, 3D printing, and virtual setups, made indirect bonding a much

easier and more predictable procedure that was worthwhile for clinicians to explore.

II. Aligners

By the late 1990s, clear aligner therapy was introduced by Align Technology as Invisalign and led the way in using a virtual model, creating a virtual treatment plan, virtual setups, and manufacturing appliances with the help of software developers to design and create their own in-house aligners. A low to moderate level of evidence exists regarding the efficiency of clear aligner therapy for certain tooth movements, especially rotational and extrusive movements. Overall orthodontic outcomes are acceptable according to Robertson et al. systematic review¹⁴, which is inconsistent with the systematic review Papageorgiou et al that reported that current evidence does not support the clinical use of aligners as an orthodontic approach that is as effective as the gold standard of conventional orthodontic treatment.¹⁵ On-going studies are working on adding attachments with the help of software predictability to control tooth movement in three spatial planes; hopefully in few years, well-conducted trials will provide a robust conclusion.

III. Retainers

Commonly clear retainer is vacuum formed/thermoformed on plaster model and have acceptable level of accuracy and mechanical properties. Latest evidence proved that 3D printing with integration of digital models enhanced accuracy and mechanical properties obtained from 3D printed removable retainers and also 3D printed fixed retainers.^{16,17}

Benefits of Digital Orthodontics

1. Improved Accuracy and Precision

Digital technologies significantly improve the accuracy and precision of orthodontic diagnostics and treatment planning. Intraoral scanners and 3D imaging systems eliminate the potential for human error associated with traditional methods, ensuring that the digital models and images are highly detailed and reliable. This enhanced accuracy leads to better-fitting appliances, more predictable tooth movement, and a higher success rate for orthodontic treatments.

2. Reduced Treatment Times

The use of digital tools, such as CAD/CAM systems and 3D printing, streamlines the process of designing and manufacturing orthodontic appliances.

This reduction in the time required for appliance fabrication and the increased speed of treatment planning ultimately leads to shorter treatment times. Additionally, the use of virtual treatment simulations allows orthodontists to identify the optimal treatment approach more quickly, reducing the overall time needed for each patient's care.

3. Enhanced Patient Experience

Patients benefit from the comfort, speed, and accuracy offered by digital orthodontics. The use of intraoral scanners eliminates the discomfort of traditional impressions, improving patient satisfaction. Digital tools also facilitate better communication between the orthodontist and patient, as virtual models and simulations can be shown and explained in real-time. Furthermore, the reduced need for multiple in-person appointments means patients spend less time in the office, enhancing convenience.

4. Customization and Personalization

Digital orthodontics allows for greater customization of treatment plans. Through the use of 3D modeling and AI, orthodontists can design appliances and aligners that are tailored specifically to a

patient's unique dental anatomy and treatment goals. This high degree of personalization ensures that each patient receives a treatment plan that is optimized for their needs, leading to better outcomes and greater satisfaction.

Challenges in Digital Orthodontics

1. High Initial Costs

One of the primary challenges associated with the implementation of digital technologies in orthodontics is the high initial investment required for equipment, software, and training. Intraoral scanners, 3D imaging devices, and CAD/CAM systems can be expensive, and smaller practices may struggle to afford the upfront costs. Despite the long-term benefits, including improved efficiency and better patient outcomes, the financial barrier can be a deterrent for some orthodontists.

2. Learning Curve and Technical Expertise

While digital tools are highly beneficial, they also require a certain level of technical expertise to use effectively. Orthodontists must invest time and resources into learning how to operate complex systems, and staff must be trained to manage the digital workflow. The

learning curve associated with new technologies can be steep, particularly for practitioners who are accustomed to traditional methods.

3. Data Security Concerns

With the increasing use of digital technologies in orthodontics comes the need for robust data security measures. Patient information, including 3D scans and treatment plans, must be stored securely to protect against breaches and unauthorized access. Orthodontic practices must ensure that they are compliant with regulations, such as the Health Insurance Portability and Accountability Act (HIPAA), to safeguard sensitive patient data.

Future Directions in Digital Orthodontics

The future of digital orthodontics looks promising, with continued advancements in AI, 3D printing, and teleorthodontics expected to further revolutionize the field. One area of significant potential is the integration of AI-driven treatment planning that can continuously learn from patient outcomes and refine its predictions over time. Additionally, the use of augmented reality (AR) and virtual reality (VR) technologies may enable

orthodontists to visualize treatment outcomes in new ways, enhancing their ability to make precise adjustments.

As digital orthodontics becomes more accessible and affordable, the use of these technologies is expected to expand across the global dental community, improving the quality of care and patient outcomes worldwide.

Conclusion

Digital orthodontics represents a paradigm shift in the field, offering increased precision, improved treatment planning, and enhanced patient satisfaction. The integration of advanced technologies such as intraoral scanners, CAD/CAM systems, 3D printing, and AI has transformed orthodontic practices, providing orthodontists with powerful tools to customize treatments and optimize outcomes. While challenges remain, such as high initial costs and technical learning curves, the long-term benefits of digital orthodontics are clear. As technology continues to evolve, digital orthodontics will play an increasingly central role in the future of orthodontic care.

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Review Article

Buccal Shelf Implants for Mandibular Distalization: A Comprehensive Analysis

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Abstract

Buccal shelf implants have revolutionized orthodontic practice by providing reliable skeletal anchorage for mandibular arch distalization. These implants, placed in the thick cortical bone lateral to the mandibular molars, offer exceptional primary stability for orthodontic loading. The present overview discusses the anatomical foundations, placement techniques, radiographic assessment methods, clinical applications, and treatment outcomes associated with using buccal shelf implants for mandibular distalization. The effectiveness of these extra-radicular implants for managing sagittal discrepancies, particularly in borderline Class III malocclusions, has expanded the scope of non-surgical orthodontic treatment. Current evidence suggests that buccal shelf implants enable significant posterior movement of the mandibular dentition without requiring patient compliance, thereby providing clinicians with a valuable tool for addressing complex orthodontic challenges.

Keywords: *Buccal shelf implants, Mandibular distalization, Skeletal anchorage, Class III malocclusion, ATM technique*

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Introduction

Orthodontic treatment of malocclusions often requires reliable anchorage to achieve desired tooth movements without unwanted

reciprocal effects. Traditional anchorage methods, including headgear and intermaxillary elastics, depend heavily on patient compliance and may produce unpredictable results. The introduction of

skeletal anchorage devices has dramatically transformed orthodontic practice by providing stable anchorage points that are independent of patient cooperation.

Among the various skeletal anchorage systems, buccal shelf implants have gained significant attention for their effectiveness in mandibular arch distalization. These implants are strategically placed in the buccal shelf region, which is characterized by thick cortical bone lateral to the mandibular molars. The unique placement of these extra-radicular implants allows orthodontists to apply distalization forces to the entire mandibular arch without causing unwanted movements of adjacent teeth.

The effectiveness of buccal shelf implants for distalization is particularly evident in the management of Class III malocclusions, where they facilitate posterior movement of the mandibular dentition without reciprocal effects on the maxillary arch. This capability has expanded treatment possibilities for borderline surgical cases, potentially eliminating the need for orthognathic surgery in selected patients with moderate skeletal discrepancies.

The present overview examines the anatomical foundations, placement

techniques, radiographic assessment methods, clinical applications, and treatment outcomes associated with using buccal shelf implants for mandibular distalization.

Anatomical Foundations of Buccal Shelf Implants

The mandibular buccal shelf represents a specialized anatomical region that provides optimal conditions for extra-alveolar bone screw placement. This region is characterized by the presence of thick cortical bone lateral to the mandibular molars, specifically in the area distal to the second molar. Anatomical studies have confirmed that this region offers high quality and quantity of bone, which ensures primary stability of implants and reduces the risk of failure during orthodontic loading. The buccal shelf area has gained prominence as an extra-alveolar anchorage site due to its biomechanical advantages and consistently low failure rates when implants are properly positioned.

Cortical bone thickness in the buccal shelf region demonstrates consistent patterns across different skeletal arrangements. Research indicates that cortical bone thickness increases distally from the first molar to the second molar in patients with varying skeletal patterns. This progressive increase in bone thickness creates an anatomical gradient that

orthodontists can leverage when determining optimal implant placement. The greatest cortical bone thickness is typically observed distal to the second molar, approximately 7 mm vertically from the alveolar crest, particularly when the implant is placed at a 30-degree angulation to the long axis of the tooth.

The anatomical variations in buccal shelf morphology across different skeletal patterns necessitate a customized approach to implant placement. CBCT studies examining the buccal shelf region have revealed variations in thickness and angulation among individuals with prognathic versus retrognathic mandibles, as well as between vertical and horizontal growth patterns. These variations highlight the importance of pre-surgical assessment of the buccal shelf region to optimize implant placement and maximize stability during distalization mechanics.



Technical Aspects of Buccal Shelf Implant Placement

The precise placement of buccal shelf implants is critical to their success and effectiveness in mandibular distalization. Bone screws utilized for buccal shelf implantation are typically available in lengths of 10-14 mm with a diameter of 2 mm, which distinguishes them from conventional interradicular mini implants. The larger dimensions of these implants enable greater bone-implant contact, enhancing primary stability during orthodontic loading. Specifically for mandibular applications, bone screws are commonly available in 10 mm and 12 mm lengths with a standard diameter of 2 mm, though specific dimensions may vary between manufacturers.

Identifying the optimal insertion site represents a fundamental consideration in buccal shelf implant placement. Research has consistently identified the area distal to the mandibular second molar as the preferred site for buccal shelf implant placement. This recommendation stems from the finding that maximum cortical bone thickness occurs in this region, which provides enhanced primary stability. The vertical position for optimal placement is approximately 7 mm from the alveolar crest, particularly when the implant is inserted at a 30-degree angulation relative to the tooth's long axis.

Angulation of implant insertion significantly influences the success and stability of buccal shelf implants. While perpendicular placement (90 degrees) has been traditionally employed, research indicates that angled placement (30 degrees) may provide superior outcomes in specific anatomical situations. The angled approach increases the length of the implant that engages with cortical bone, thereby enhancing stability during distalization mechanics. This technical modification has particular relevance when addressing anatomical limitations such as limited bone thickness or proximity to vital structures.

Avoiding damage to adjacent anatomical structures, particularly molar roots, is paramount when placing buccal shelf implants. The success of buccal shelf implants depends largely on their proper placement in extra radicular regions away from the roots of mandibular molars. Improper positioning can result in root damage, implant failure, and compromised treatment outcomes. This concern highlights the importance of precise pre-surgical planning and post-insertion radiographic verification to ensure optimal implant positioning for distalization mechanics.



Radiographic Assessment Techniques for Buccal Shelf Implants

The accurate assessment of buccal shelf implant positioning is essential for ensuring treatment success and preventing iatrogenic complications. CBCT has emerged as the gold standard for evaluating the skeletal structure of the buccal shelf region, enabling three-dimensional visualization of the implant in relation to adjacent structures. This imaging modality allows for precise measurement of cortical bone thickness, assessment of the optimal placement angle, and quantification of bone-implant contact at the interface lateral to molar roots. Despite these advantages, the increased radiation exposure and cost associated with CBCT have prompted the development of alternative assessment approaches.

The Arvind's Trans Mandibular (ATM) technique represents an innovative radiographic approach for assessing buccal shelf implant placement using conventional intraoral periapical radiography or radiovisiography. This modified extraoral technique was developed to overcome the limitations of traditional methods by utilizing standard dental radiographic equipment available in most clinical settings. The technique involves placing an IOPA film or RVG sensor beneath the lower border of the mandible with the patient's head tilted upward and sideways by approximately 20 degrees toward the contralateral side of implant placement. This orientation aligns the lower border of the mandible parallel to the floor, facilitating optimal visualization of the implant-tooth relationship.

Implementation of the ATM technique requires specific positioning parameters to achieve diagnostic images. The sensor is positioned outside the patient's mouth along the mandibular inferior border, as medial as the soft tissues permit, and angled 20-30 degrees facing the X-ray tube. Concurrently, the X-ray tube is positioned lateral to the eye and angulated 70-80 degrees to the horizontal plane, creating perpendicular with the sensor. This configuration produces

an axial view along the first molar region, clearly displaying the relationship between the buccal shelf implant and the molar roots. The radiographic image obtained through this technique enables visualization of any gap between the implant and molar roots, confirming safe placement without damage to adjacent structures.

The verification of radiographic findings using multiple assessment techniques enhances diagnostic confidence. In clinical validation studies, the ATM technique demonstrated high accuracy in assessing post-operative buccolingual implant positioning relative to molar roots, with findings comparable to those obtained through CBCT imaging. This correlation suggests that the ATM technique can serve as a viable, low-radiation alternative for routine assessment of buccal shelf implant placement. In instances where the ATM technique reveals potential proximity to molar roots, tube shift modification of the technique can provide additional spatial information prior to considering more advanced imaging options.



Clinical Applications for Mandibular Distalization

Buccal shelf implants provide versatile applications in contemporary orthodontic practice, with mandibular arch distalization representing their primary clinical function. These extra-radicular implants have demonstrated effectiveness in the management of Class III malocclusions, allowing for significant posterior movement of the mandibular dentition without relying on patient compliance. The capacity for full-arch distalization using buccal shelf anchorage has expanded treatment possibilities for borderline surgical cases, potentially eliminating the need for orthognathic surgery in selected patients with moderate skeletal discrepancies.

The strategic placement of buccal shelf implants enables various biomechanical approaches to mandibular distalization. In cases requiring unilateral distalization,

implants can be placed on the affected side to facilitate targeted movement of specific segments. Alternatively, bilateral placement provides symmetrical anchorage for comprehensive arch distalization in patients requiring total arch management. This flexibility in application permits customized treatment planning based on the specific malocclusion characteristics and treatment objectives.

Beyond distalization, buccal shelf implants offer additional clinical applications that expand their utility in orthodontic practice. These include retraction of lower anterior teeth, intrusion of posterior segments, and management of retreatment cases where extractions have previously been performed. Their versatility stems from the stable anchorage they provide, which enables precise control of orthodontic forces without reciprocal movements that might compromise treatment outcomes. This combination of stability and versatility has positioned buccal shelf implants as valuable adjuncts in contemporary orthodontic practice.

The implementation of buccal shelf implants for distalization requires careful case selection and biomechanical planning. When the buccal shelf region is inadequate or steep, placement of implants in the extra radicular area around

lower molars becomes technically challenging. In such scenarios, comprehensive pre-treatment assessment, possibly including CBCT imaging, becomes essential to identify suitable alternative placement sites or consider modified treatment approaches. This individualized approach to treatment planning optimizes outcomes while minimizing potential complications associated with buccal shelf implant-based distalization.

Treatment Outcomes and Effectiveness

The clinical effectiveness of buccal shelf implants for mandibular distalization has been substantiated through multiple clinical applications. These implants have demonstrated consistent success in achieving Class III malocclusion correction by facilitating posterior movement of the mandibular dentition. The literature documents numerous cases where buccal shelf implant-anchored distalization has produced treatment outcomes comparable to those achieved through orthognathic surgery, particularly in borderline cases with moderate skeletal discrepancies. This equivalence in treatment outcome, combined with reduced invasiveness and cost, has positioned buccal shelf implants as

valuable alternatives to surgical intervention in selected cases.

Radiographic assessment of treatment outcomes confirms the stability of buccal shelf implants during orthodontic loading. Clinical cases evaluated using the ATM technique and verified with CBCT imaging demonstrate maintenance of proper implant positioning throughout the distalization process. The presence of consistent gaps between implants and molar roots throughout treatment suggests that properly positioned buccal shelf implants maintain their extra radicular location despite application of orthodontic forces. This stability contributes to reduced risk of root damage and enhanced treatment predictability when using these implants for mandibular distalization.

The biomechanical advantage of buccal shelf implants in distalization stems from their extra radicular positioning and engagement with thick cortical bone. This configuration creates a stable anchorage unit capable of withstanding continuous orthodontic forces without displacement. The resultant force system enables bodily movement of the mandibular dentition with minimal tipping, producing more favourable occlusal relationships than might be achieved with conventional anchorage methods. This

biomechanical efficiency translates to reduced treatment time and enhanced clinical outcomes in patients requiring significant mandibular distalization.

Limitations and Future Directions

Despite their effectiveness, buccal shelf implants for distalization present certain limitations that warrant consideration. The anatomical variability of the buccal shelf region across different skeletal patterns necessitates individualized assessment and planning. In patients with deficient buccal shelf areas or steep mandibular angles, implant placement becomes technically challenging and may require modified approaches or alternative anchorage strategies. Additionally, the proximity of the buccal shelf region to the mandibular molars creates potential for root damage if precise placement protocols are not followed.

The radiographic assessment of buccal shelf implants presents both opportunities and challenges for clinical practice. While innovative techniques like the ATM approach offer accessible alternatives to advanced imaging, their accuracy depends on proper implementation and interpreter experience. The learning curve associated with these techniques may limit their immediate adoption in general practice

settings. Additionally, cases requiring implant repositioning necessitate repeated radiographic assessment, potentially increasing radiation exposure if conventional techniques are exclusively employed.

Future research directions should focus on optimizing buccal shelf implant design specifically for distalization purposes. Current implants, while effective, were not originally designed exclusively for this application. Development of implants with configuration and dimensions specifically engineered for the buccal shelf region could enhance stability and simplify placement procedures. Additionally, long-term studies evaluating the stability of distalization outcomes achieved using buccal shelf implants would provide valuable insights into the durability of treatment results and inform refinement of clinical protocols.

Conclusion

Buccal shelf implants represent a significant advancement in orthodontic anchorage systems, providing reliable skeletal support for mandibular distalization without requiring patient compliance. The anatomical characteristics of the buccal shelf region, particularly the thick cortical bone distal to the second molar, create ideal conditions for

implant stability during orthodontic loading. Technical refinements in implant design, placement protocols, and radiographic assessment have enhanced the predictability and safety of these procedures, expanding their clinical applications in contemporary orthodontic practice.

The effectiveness of buccal shelf implants for distalization is particularly evident in the management of Class III malocclusions, where they facilitate posterior movement of the mandibular dentition without reciprocal effects on the maxillary arch. This capability has expanded treatment possibilities for borderline surgical cases, potentially eliminating the need for orthognathic surgery in selected patients with moderate skeletal discrepancies. As research continues to refine placement techniques and optimize implant design, buccal shelf implants will likely assume an increasingly prominent role in the management of sagittal discrepancies through orthodontic distalization.

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Review Article**Nanobiofusion gingival gel in fixed orthodontics induced gingivitis**

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Abstract

The primary goal of fixed orthodontic treatment is to attain the ideal occlusion with function and stability using tooth movement to the optimum position by alteration of the periodontium.^{1,2} Orthodontic treatment with fixed appliances, such as braces, often leads to gingivitis, a common side effect caused by plaque accumulation around the orthodontic hardware. This condition, known as orthodontic-induced gingivitis, can significantly impact a patient's oral health if not managed properly. Traditional methods for controlling gingival inflammation, such as antiseptic mouthwashes, are often limited by their ability to adequately target the root causes of the condition. Nanobiofusion Gingival Gel, an innovative product combining nanotechnology with bioactive compounds, offers a promising solution. The gel's unique nanostructure allows it to penetrate deeper into the gum tissues, releasing therapeutic agents that target inflammation, microbial growth, and tissue regeneration. This article explores the potential of Nanobiofusion Gingival Gel in managing orthodontic-induced gingivitis, examining its composition, mechanism of action, clinical efficacy, and future prospects.

Keywords: *Orthodontic-induced gingivitis, nanobiofusion, gingival gel, fixed orthodontics, nanotechnology, antimicrobial agents, bioactive compounds, tissue regeneration, oral care.*

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Introduction

Fixed orthodontic appliances, such as braces, are widely used to straighten teeth and correct dental malocclusions. While highly effective in achieving these goals, these devices introduce challenges for maintaining optimal oral hygiene. The literature verifies several diverse conditions accompanying fixed orthodontic treatment.⁴ Bacterial plaque is the single essential causative factor of periodontal disease which is in agreement among researchers.⁵ Brackets and wires often trap food particles and plaque, leading to an increased risk of gingival inflammation. This inflammation, known as orthodontic-induced gingivitis, is marked by symptoms such as red, swollen, and bleeding gums, and can significantly impact patient comfort and oral health.

The cause of orthodontic-induced gingivitis is multifactorial, involving mechanical irritation from the orthodontic hardware, difficulties in cleaning the areas around brackets and wires, and an increase in plaque and bacterial accumulation. As a result, standard oral hygiene practices may not be sufficient to prevent or reduce the inflammation, leading to a need for adjunctive treatments.

Nanotechnology has taken human kind to an entirely new period of improvement in

which we have new beneficial options.³ Nanobiofusion Gingival Gel represents a promising solution to address this issue. The gel incorporates advanced nanotechnology that allows for the controlled release of active ingredients at the site of inflammation. These bioactive compounds include anti-inflammatory agents, antioxidants, and antimicrobial substances that not only reduce swelling but also inhibit bacterial growth, ultimately promoting the healing of the gingival tissues.

This article reviews the composition, mechanism, clinical efficacy, and future prospects of Nanobiofusion Gingival Gel in the management of orthodontic-induced gingivitis.

Mechanism of Action of Nanobiofusion Gingival Gel

The primary therapeutic action of Nanobiofusion Gingival Gel is based on the synergy of nanotechnology and bioactive compounds. Nanotechnology enables the precise formulation of particles small enough to penetrate the epithelial and subepithelial layers of the gingival tissue. These nano-sized particles increase the surface area of the gel, enhancing the absorption and release of the active ingredients into the gingiva.

Nanostructure and Controlled Release

The nanostructure of the gel allows for a sustained release of active ingredients. Traditional oral care products often provide only short-term relief, whereas Nanobiofusion Gingival Gel's advanced formulation ensures that its therapeutic effects are prolonged. The gel's controlled-release mechanism maintains a consistent level of the active compounds at the site of inflammation, promoting faster recovery and reduced microbial growth.

Anti-inflammatory and Antimicrobial Action

The gel contains anti-inflammatory agents, such as natural extracts, that help reduce the inflammatory response in the gingival tissues. In addition to its anti-inflammatory effects, the gel incorporates antimicrobial compounds that reduce bacterial load, a key contributor to orthodontic-induced gingivitis. By controlling the microbial environment, the gel prevents further irritation of the gums and helps maintain oral hygiene.

Composition of Nanobiofusion Gingival Gel

Nanobiofusion Gingival Gel is formulated with a combination of natural plant extracts,

antioxidants, and antimicrobial agents. Some of the key ingredients include:

Essential Oils and Plant Extracts: These ingredients, such as aloe vera and chamomile, have well-known anti-inflammatory and soothing properties that reduce gum irritation .

Antioxidants: Antioxidants, such as vitamin E and C, promote healing and reduce oxidative stress in the gingival tissues .

Nanoparticles: These particles, often made of lipids or polymers, help deliver the active ingredients deep into the gum tissue and ensure they stay in contact with the affected area for an extended period .

The unique blend of these ingredients not only helps to control inflammation but also contributes to the regeneration of gingival tissues and protection against further damage.

Clinical Efficacy of Nanobiofusion Gingival Gel

Numerous studies have demonstrated the effectiveness of Nanobiofusion Gingival Gel in reducing the symptoms of orthodontic-induced gingivitis. Research indicates that patients using the gel show significant improvements in gingival health, including reduced swelling,

bleeding, and redness. Additionally, patients report improved comfort during orthodontic treatment, as the gel provides a soothing effect on the irritated tissues .

Patients treated with Nanobiofusion Gingival Gel for a period of four weeks exhibited a notable reduction in the gingival index and plaque index compared to those using standard mouthwash treatments. Furthermore, the gel was found to be more effective in preventing the progression of gingivitis to more severe forms of periodontal disease.

Long-term Benefits

One of the key advantages of Nanobiofusion Gingival Gel is its potential to prevent the recurrence of gingivitis during orthodontic treatment. The gel's ability to reduce plaque accumulation and bacterial growth, combined with its anti-inflammatory properties, ensures that patients are less likely to experience repeated episodes of gingival inflammation.

Advantages Over Traditional Treatments

Traditional treatments for orthodontic-induced gingivitis typically include antiseptic mouthwashes, mechanical plaque control, and professional cleanings. However, these methods often fall short in providing long-term relief due to limited

action at the site of inflammation and difficulty in reaching all areas affected by orthodontic appliances.

Nanobiofusion Gingival Gel offers several advantages

Localized Action: The gel is applied directly to the affected gingival areas, ensuring that the active ingredients are delivered precisely where needed .

Sustained Effects: Unlike mouthwashes that wash away quickly, the gel provides a longer-lasting therapeutic effect, reducing the frequency of application.

Non-invasive and Easy to Use: The gel is simple to apply and does not interfere with orthodontic appliances, making it a convenient treatment option for patients .

Future Perspectives and Applications

As nanotechnology continues to advance, the potential applications for Nanobiofusion Gingival Gel in orthodontics and other areas of dentistry will expand. Future developments may involve incorporating additional bioactive agents, such as growth factors, to further enhance tissue healing and regeneration.

Furthermore, as more clinical trials are conducted, we expect to see more robust

evidence supporting the use of Nanobiofusion Gingival Gel in diverse patient populations, including those with more complex orthodontic treatments or pre-existing periodontal conditions.

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Unlocking the power of biomarkers in Orthodontics

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Abstract

Orthodontics has traditionally relied on clinical assessments and physical measurements to diagnose and treat malocclusions. However, the integration of biomarkers into orthodontic practice is poised to revolutionize the field by enabling a more personalized, precision-based approach to care. Biomarkers, including genetic, molecular, and cellular markers, offer valuable insights into the biological processes underlying orthodontic treatment, such as bone remodelling, inflammation, and tissue regeneration. Genetic biomarkers can predict an individual's predisposition to malocclusion and their response to treatment, while molecular biomarkers such as cytokines, growth factors, and collagen degradation products provide real-time data on tissue remodelling. Cellular biomarkers, including osteoclast and osteoblast activity markers, help monitor bone resorption and formation during orthodontic tooth movement. The application of biomarkers can improve the accuracy of treatment outcome predictions, enhance the monitoring of bone remodelling, and allow for more personalized treatment plans tailored to individual patient characteristics. Despite challenges related to standardization, cost, and ethical considerations, the future of orthodontics lies in the effective integration of biomarkers to optimize patient care, reduce complications, and improve treatment efficiency. This paper explores the types of biomarkers used in orthodontics, their clinical applications, and their potential to shape the future of orthodontic care.

Keywords: *Biomarkers, Genetic biomarkers, Molecular biomarker, Cellular biomarkers, Bone remodelling.*

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Introduction

Orthodontics, a specialized branch of dentistry that focuses on diagnosing, preventing, and treating malocclusions (misalignments of teeth and jaws), has traditionally relied on clinical evaluations, radiographs, and physical measurements to formulate treatment plans. However, recent advances in biomarker research have begun to provide deeper insights into the biological processes underlying orthodontic treatment, leading to a shift toward more personalized, precision-based approaches in orthodontic care. Biomarkers are measurable indicators of biological conditions or processes that can be found in various bodily fluids, such as saliva, blood, or urine, and are already being used to better understand how orthodontic treatments affect the body and how the body responds to them.

The integration of biomarkers into orthodontics could revolutionize the field by allowing clinicians to better understand individual patient responses to treatment, predict outcomes, monitor progress more effectively, and mitigate potential complications. This article explores the various types of biomarkers used in orthodontics, their applications in clinical practice, and how they could help improve orthodontic care in the future.

Types of Biomarkers in Orthodontics

Biomarkers can be broadly categorized into genetic, molecular, and cellular markers. These biomarkers hold promise in improving the effectiveness and precision of orthodontic treatments, offering a more personalized approach to care.

1. Genetic Biomarkers

Genetic biomarkers refer to specific genetic variations or mutations that can predict an individual's predisposition to orthodontic conditions, as well as their response to orthodontic treatments. These biomarkers are especially valuable in understanding the genetic basis of malocclusions and other craniofacial abnormalities, which are often influenced by inheritance patterns.

- **Genetic predisposition to malocclusion:** Studies have identified a number of genes associated with craniofacial development, which may influence the likelihood of malocclusions. Genes such as **MSX1**, **RUNX2**, and **PAX9** have been shown to be linked to various forms of malocclusion, such as Class II and Class III malocclusions, as well as cleft lip and palate.³ For example, mutations in the **MSX1** gene have been found to play a significant role in dental development,

which may contribute to orthodontic conditions like missing teeth or tooth crowding.³

- **Bone response to orthodontic forces:** The rate of tooth movement in response to orthodontic forces is influenced by genetic factors. Certain genetic markers, such as those involved in bone metabolism, can impact the speed and efficiency of tooth movement. For instance, genetic variations in the **COL1A1** gene, which encodes collagen, have been shown to influence bone remodelling and orthodontic tooth movement.⁸ Identifying these genetic markers in patients could help orthodontists predict how a patient will respond to orthodontic treatment, allowing for more personalized treatment plans.
- **Craniofacial developmental disorders:** In addition to general malocclusion, specific genetic conditions such as **cleft lip and palate** are caused by particular mutations. Genetic testing can help identify at-risk individuals early, allowing for specialized orthodontic interventions to address developmental anomalies.

2. Molecular Biomarkers

Molecular biomarkers are biomarkers that provide insights into specific molecular processes occurring within the body. In orthodontics, these markers are crucial for monitoring bone remodelling, inflammation, and tissue healing during treatment.

- **Cytokines and growth factors:** Cytokines such as **interleukin-1 beta (IL-1 β)** and **tumor necrosis factor-alpha (TNF- α)** play a pivotal role in the inflammatory response and are often elevated in response to orthodontic forces. Orthodontic tooth movement leads to inflammation in the periodontal ligament and surrounding tissues, triggering the release of these cytokines.⁷ Understanding the molecular signaling pathways involving cytokines can provide valuable insights into the rate of tooth movement and the body's response to the applied forces.

Additionally, **growth factors** such as **transforming growth factor-beta (TGF- β)** and **vascular endothelial growth factor (VEGF)** are involved in tissue regeneration and remodelling, both of which are essential for effective tooth movement.² Monitoring the levels of these growth

factors in response to orthodontic treatment could provide orthodontists with real-time data on how well tissues are healing and remodelling.

- **Collagen degradation**

products: Orthodontic forces induce bone resorption on the pressure side of the tooth and bone formation on the tension side. These processes are closely linked to the degradation of collagen. **C-telopeptide (CTX)**, a marker of type I collagen degradation, is commonly used to assess bone turnover and can help monitor the rate of bone remodelling during orthodontic treatment.⁴ Elevated levels of CTX may indicate increased bone resorption, which is a necessary component of tooth movement.

- **Osteocalcin:** Osteocalcin is a protein secreted by osteoblasts that plays a critical role in bone formation. It has been identified as a potential molecular marker of bone formation during orthodontic treatment.⁹ Monitoring osteocalcin levels in patients undergoing orthodontic treatment could provide orthodontists with a biomarker to

assess the rate of bone deposition and predict the success of treatment.

3. Cellular Biomarkers

Cellular biomarkers are indicators of specific cells involved in the biological processes associated with orthodontic treatment. The two primary types of cells involved in orthodontic tooth movement are osteoclasts, which resorb bone, and osteoblasts, which build new bone. Cellular biomarkers help monitor the activity of these cells during orthodontic treatment.

- **Osteoclast activity:** Osteoclasts are responsible for bone resorption on the pressure side of the tooth, a critical step in orthodontic tooth movement. **Tartrate-resistant acid phosphatase (TRAP)** is a well-known marker of osteoclast activity. Elevated levels of TRAP indicate increased osteoclast activity and bone resorption, which are necessary for tooth movement to occur.
- **Osteoblast activity:** Osteoblasts are responsible for bone formation on the tension side of the tooth. Monitoring markers of osteoblast activity, such as **alkaline phosphatase (ALP)**, can provide insights into the rate of bone formation and remodelling.⁶ By

tracking osteoblast activity, orthodontists can ensure that bone formation is occurring at an appropriate rate to support proper tooth movement.

- **Periodontal ligament (PDL) cells:**

The periodontal ligament plays a central role in orthodontic tooth movement by transmitting mechanical forces between the tooth and the surrounding bone. Cellular biomarkers that reflect the activity of PDL cells, such as **matrix metalloproteinases (MMPs)**, can help assess the health and function of this tissue during orthodontic treatment.¹ Elevated levels of MMPs may indicate active remodelling of the PDL, which is necessary for effective tooth movement.

- **Applications of Biomarkers in Orthodontics**

Biomarkers have significant potential to improve orthodontic care by offering new ways to monitor treatment progress, predict outcomes, and personalize treatment plans. The primary applications of biomarkers in orthodontics include:

1. Predicting Treatment Outcomes

- One of the most valuable applications of biomarkers is their potential to predict treatment outcomes. By analyzing genetic and molecular biomarkers, orthodontists can gain insights into how a patient's body will respond to orthodontic forces, allowing for more accurate predictions of tooth movement and treatment success. For example, genetic testing for markers such as **COL1A1** or **MSX1** could provide valuable information on how a patient will respond to orthodontic treatment, enabling the orthodontist to adjust treatment plans accordingly⁸.
- Additionally, molecular markers such as **IL-1 β** and **TNF- α** could help identify patients at risk of experiencing excessive inflammation during treatment, allowing orthodontists to modify the force applied or introduce adjunctive therapies to mitigate the risk of complications.

2. Monitoring Bone Remodelling

- Bone remodelling is an essential process in orthodontic treatment. By monitoring biomarkers such as

osteocalcin and **CTX**, orthodontists can track the rate of bone resorption and formation during treatment, ensuring that the biological processes required for tooth movement are occurring at an appropriate pace. For example, an imbalance between bone resorption and formation may lead to complications such as root resorption or inadequate tooth movement. By regularly monitoring these biomarkers, orthodontists can make timely adjustments to the treatment plan to optimize results.

3. Personalizing Treatment Plans

- Each patient responds differently to orthodontic treatment, and factors such as age, genetics, and bone density play a significant role in determining treatment success. Biomarkers offer a way to tailor treatment plans to the individual characteristics of each patient. For example, if genetic testing reveals that a patient is likely to experience slower tooth movement due to variations in bone metabolism, the orthodontist can adjust the force applied or recommend adjunctive therapies such as low-level laser

therapy to enhance tooth movement.⁹

- Personalized orthodontics, driven by biomarkers, represents a move toward more efficient and effective treatments that can be better aligned with the unique needs of each patient.

• Challenges and Future Directions

Despite the promising potential of biomarkers in orthodontics, several challenges remain.

1. Standardization and Validation

For biomarkers to become widely used in clinical practice, they must be standardized and validated. Research must establish which biomarkers are most relevant for specific orthodontic conditions and treatment outcomes. Additionally, consistent and reproducible methods for measuring biomarkers are necessary to ensure reliable results across different settings.⁷

2. Cost and Accessibility

The cost of genetic testing and biomarker analysis may be a barrier to widespread adoption, especially in low-resource settings. As technology advances and the cost of testing decreases, biomarkers may

become more accessible to a larger number of patients, making personalized orthodontics a reality for more individuals.

3. Ethical Considerations

Genetic testing and the use of biomarkers raise important ethical questions, such as issues related to patient privacy, consent, and the potential for genetic discrimination. It is important to establish ethical guidelines to ensure that patient data is used responsibly and that individuals are fully informed of the implications of genetic testing.³

Conclusion

Biomarkers have the potential to transform the field of orthodontics, offering new ways to understand, monitor, and optimize treatment. From genetic markers that predict malocclusion to molecular markers that track bone remodelling, biomarkers provide orthodontists with valuable tools for improving patient care. While challenges remain in terms of standardization, cost, and ethical considerations, the future of orthodontics lies in the integration of these powerful biomarkers into clinical practice. As research in this field progresses, biomarkers will play an

increasingly vital role in providing personalized, efficient, and effective orthodontic care. The era of biomarker-driven orthodontics has begun, and the possibilities are endless.

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Review Article**Obstructive Sleep Apnea and The Role Of Orthodontics**

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Abstract

Obstructive Sleep Apnea (OSA) is a common yet often underdiagnosed sleep disorder characterized by repeated episodes of upper airway collapse during sleep, leading to intermittent hypoxia and sleep fragmentation. The condition is associated with significant health risks, including cardiovascular disease, metabolic dysfunction, and cognitive impairment. This article explores the role of orthodontics in the management of OSA, focusing on how orthodontic interventions can aid in airway modification, prevent upper airway obstruction, and complement multidisciplinary treatment approaches. A comprehensive review of current literature was conducted to assess the relationship between craniofacial morphology and OSA, along with the efficacy of various orthodontic treatments, such as mandibular advancement devices (MADs), rapid maxillary expansion (RME), and orthognathic surgery. Evidence suggests that certain craniofacial anomalies—such as retrognathia, narrow maxillary arches, and vertical growth patterns—contribute to airway constriction and OSA risk. Orthodontic strategies like RME have shown promise in expanding the nasal cavity and improving airflow, particularly in pediatric patients. MADs serve as a non-invasive option for mild to moderate OSA in adults by advancing the mandible and increasing upper airway patency. Additionally, orthognathic surgery can provide long-term airway benefits for patients with severe skeletal discrepancies. Orthodontists play a crucial role in the early identification and management of OSA by recognizing craniofacial risk factors, collaborating with sleep medicine specialists, and offering tailored treatment plans. Future research should continue to explore innovative orthodontic techniques and their long-term impact on airway health.

Keywords: *Obstructive sleep apnea , sleep patterns, enlarged tongue, CPAP Therapy, Mandibular advancement devices.*

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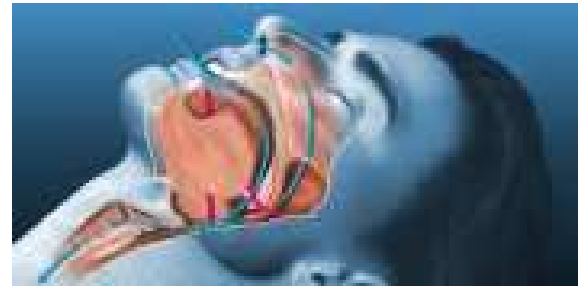
Introduction

Obstructive Sleep Apnea (OSA) is a prevalent sleep disorder characterized by repeated episodes of partial or complete obstruction of the upper airway during sleep, leading to disrupted sleep patterns and decreased oxygen saturation. OSA is associated with various health complications, including cardiovascular diseases, metabolic disorders, and impaired cognitive function. Traditional management strategies, such as Continuous Positive Airway Pressure (CPAP) therapy, often face challenges related to patient compliance. This has led to an increased interest in alternative and adjunctive treatments, notably within the field of orthodontics. Orthodontic interventions aim to address craniofacial anomalies contributing to airway obstruction, offering both preventive and therapeutic benefits for OSA patients.

Pathophysiology of Obstructive Sleep Apnea

OSA occurs due to the collapse of the pharyngeal airway during sleep, resulting from a combination of anatomical and neuromuscular factors. Key anatomical contributors include a retropositioned mandible, enlarged tongue, hypertrophic soft tissues, and a narrowed maxilla. These

structural abnormalities reduce the airway space, increasing the likelihood of obstruction during sleep. Neuromuscular factors, such as reduced muscle tone during sleep, further exacerbate this condition.



Predisposing factors.¹

- Obesity
- Presence of structural abnormalities that causes upper airway obstruction
- increasing age
- male gender
- smoking and alcohol consumption
- sedative drugs
- micrognathia
- adenoids
- retrognathia
- enlarged tonsils
- enlarged tongue

Risk factors

Conditions that act as risk factors of OSA in adults include obesity (body mass index [BMI], menopause, male sex, and

increasing age. Some craniofacial anomalies are also associated with OSA.²

Symptoms

- history of snoring
- gasping respiration or choking
- apneas during sleep
- nocturnal awakenings
- morning headaches
- increased daytime sleepiness.

The severity of adult OSA is classified as mild ($5 \leq \text{AHI} < 15$ events/h), moderate ($15 \leq \text{AHI} < 30$ events/h), or severe ($\text{AHI} \geq 30$ events/h).³

Treatment Of OSA

Positive airway pressure (PAP) therapy is the gold standard treatment for obstructive sleep apnea, it can be provided either by continuous positive airway pressure (CPAP), bilevel positive airway pressure (BPAP), or autotitrating positive airway pressure (APAP).



Orthodontic Interventions in OSA Management

Orthodontic treatments have emerged as valuable options in the multidisciplinary approach to managing OSA. Effective orthodontic treatments may include orthognathic surgery with maxillomandibular advancement and mandibular advancement devices. The negative effects of the latter make this a choice of last resort. Current research indicates that OSA alone is not sufficient indication for palatal expansion.⁴ These interventions primarily focus on modifying craniofacial structures to enhance airway patency.

Orthodontic Records Helpful in Management Are:

A low position of the hyoid bone when measured from the inferior border of the mandible has been shown to be an indicator of low muscle tonicity and in literature it has been linked with OSA.

Airway imaging with the use of a lateral cephalogram may not give accurate information. CBCT images are useful as diagnostic aid in routine orthodontic treatment. CBCT provides no information on actual function of the airway or neuromuscular tonicity.

Key orthodontic strategies include:

1. Rapid Maxillary Expansion (RME):

RME is an orthodontic procedure aimed at widening the maxillary arch by separating the midpalatal suture, thereby increasing the transverse dimension of the maxilla. This expansion leads to an increase in nasal cavity volume, reducing nasal resistance and improving airflow. Studies have demonstrated that RME can significantly decrease the Apnea-Hypopnea Index (AHI) in pediatric patients with OSA, with sustained benefits observed over long-term follow-ups.

2. Mandibular Advancement Devices (MADs):

MADs are oral appliances designed to reposition the mandible anteriorly during sleep, thereby enlarging the upper airway and preventing collapse. These devices are particularly effective in patients with mild to moderate OSA and have been associated with improvements in AHI and daytime sleepiness. Patient compliance and proper device fitting are critical for the success of this therapy.

3. Twin Block Appliance: The Twin Block is a functional orthopedic appliance commonly used in growing children to correct Class II malocclusions by advancing the mandible. Beyond dental corrections, this appliance has been shown to improve airway dimensions, thereby

reducing the severity of OSA. Improved facial aesthetics and enhanced self-esteem are additional benefits associated with its use.

4. Maxillomandibular Advancement (MMA):

MMA is a surgical procedure that advances both the maxilla and mandible, effectively enlarging the pharyngeal airway. This intervention is considered one of the most effective surgical treatments for OSA, particularly in patients with significant craniofacial abnormalities or those who have not responded to other treatments. MMA has demonstrated high success rates in reducing AHI and improving overall quality of life.

5. Mini-Implant Assisted Rapid Palatal Expansion (MARPE):

For adults with transverse maxillary deficiency, traditional RME may be less effective due to the fusion of the palatal sutures. MARPE utilizes mini-implants to facilitate maxillary expansion in adults, leading to increased nasal cavity volume and improved airflow. This technique offers a minimally invasive alternative to surgical expansion procedures.

The negative influence of the headgear on the upper airway volume may be assumed, due to maxillary growth restriction

Kirjavainen and Kirjavainen⁵ reported that treatment with cervical headgear increased

the velopharyngeal dimensions yet did not affect the rest of the oropharynx and hypopharynx.⁶

Clinical Considerations and Patient Selection

The success of orthodontic interventions in managing OSA depends on careful patient selection and comprehensive evaluation. Key considerations include:

Severity of OSA: Orthodontic treatments like MADs are generally recommended for patients with mild to moderate OSA, while surgical interventions such as MMA may be reserved for severe cases or when anatomical abnormalities are pronounced.

Age and Growth Potential: In growing children, functional appliances like the Twin Block can harness natural growth to correct jaw discrepancies and improve airway dimensions. In adults, where growth potential is limited, alternative approaches like MARPE or surgical interventions may be more appropriate.

Craniofacial Anatomy: A thorough assessment of craniofacial structures is essential to identify anatomical contributors to airway obstruction. This evaluation guides the selection of appropriate orthodontic or surgical interventions tailored to the individual's anatomical needs.

Patient Compliance: The effectiveness of removable appliances, such as MADs, heavily relies on patient adherence to prescribed usage. Ensuring patient education and addressing potential barriers to compliance are crucial for successful outcomes.

Conclusion

Orthodontic interventions play a pivotal role in the comprehensive management of Obstructive Sleep Apnea, offering both preventive and therapeutic benefits. The effects of untreated sleep apnea on daily activities are multiple and it includes excessive daytime sleepiness, impaired cognitive function, mood elevations and personality changes⁷. By addressing craniofacial anomalies that contribute to airway obstruction, these treatments can significantly improve airway patency, reduce the severity of OSA, and enhance patients' quality of life. A multidisciplinary approach, involving orthodontists, sleep specialists, and other healthcare professionals, is essential to tailor treatment plans to individual patient needs, ensuring optimal outcomes in the management of OSA.

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The efficacy of a fluoride varnish in reducing enamel demineralization adjacent to orthodontic brackets

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Abstract

Orthodontic treatment, while enhancing dental alignment, often leads to enamel demineralization adjacent to orthodontic brackets, which may result in white spot lesions (WSLs) and, if left untreated, progress to dental caries. Fluoride varnishes are widely used to mitigate this issue due to their potential to remineralize enamel and prevent further demineralization. This article reviews various fluoride varnishes, including sodium fluoride (NaF), acidulated phosphate fluoride (APF), amine fluoride, and stannous fluoride, and their efficacy in preventing enamel demineralization around orthodontic brackets. NaF varnish is most commonly recommended due to its proven effectiveness and safety, but amine and stannous fluoride varnishes offer unique advantages such as enhanced remineralization potential and antibacterial properties. The choice of varnish should be tailored to individual patient needs based on factors like plaque accumulation and risk of enamel demineralization. Fluoride varnishes remain a critical preventive measure in orthodontics, helping to maintain the health and aesthetics of the teeth throughout treatment.

Keywords: Enamel demineralization, White spot lesions (WSLs), Fluoride varnishes, Sodium fluoride (NaF) varnish, Acidulated phosphate fluoride (APF) varnish, Amine fluoride varnish

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Introduction

Orthodontic treatment, while effective in improving dental alignment, poses significant challenges in maintaining oral hygiene, particularly around the orthodontic brackets. The constant presence of brackets and wires creates an environment where plaque accumulation is more likely, leading to enamel demineralization and white spot lesions (WSLs). These lesions are an early sign of enamel decay that can develop adjacent to orthodontic brackets, a concern for both patients and orthodontists. To mitigate this issue, fluoride varnishes have been proposed as an effective preventive measure due to their ability to remineralize enamel and prevent further demineralization. This article examines the effectiveness of various types of fluoride varnishes in preventing enamel demineralization adjacent to orthodontic brackets, focusing on their mechanisms of action, clinical outcomes, and comparisons between different varnishes. It will review existing literature and provide insight into the best fluoride varnish options for orthodontic patients.

Enamel Demineralization and the Role of Orthodontic Brackets

Enamel demineralization refers to the loss of mineral content from the enamel, leading to the weakening of the tooth structure. During orthodontic treatment, the presence of brackets and wires complicates oral hygiene, creating areas where plaque can accumulate. The difficulty in cleaning these areas, combined with an increased intake of cariogenic foods and beverages, creates an ideal environment for demineralization to occur. This process is initiated when acids produced by bacteria in plaque dissolve calcium and phosphate from the enamel surface.⁷ The areas adjacent to orthodontic brackets are particularly susceptible to demineralization due to the difficulty in thoroughly cleaning the surfaces around the brackets. As a result, white spot lesions often appear around the brackets, representing the initial stages of enamel decay. Left untreated, these lesions can progress to more severe forms of dental caries, which can compromise the aesthetics and long-term health of the teeth.

Fluoride as a Preventive Measure

Fluoride has long been recognized as a potent agent in preventing dental caries. It works through several mechanisms, including:

- Inhibition of enamel demineralization: Fluoride reduces the solubility of enamel by forming fluorapatite crystals, which are more resistant to acid dissolution.
- Enhancement of enamel remineralization: Fluoride can aid in the repair of enamel by promoting the redeposition of lost minerals, particularly calcium and phosphate.
- Antibacterial effects: Fluoride has been shown to inhibit bacterial metabolism, reducing acid production and bacterial plaque formation.

For orthodontic patients, fluoride varnishes offer a convenient and effective way to deliver fluoride directly to the enamel surface. Varnishes are designed to adhere to the teeth, providing a longer-lasting fluoride effect compared to other fluoride delivery methods, such as rinses or gels.⁸

Types of Fluoride Varnishes

Fluoride varnishes come in several formulations, each containing varying concentrations of fluoride and other components that may influence their effectiveness. The most commonly used fluoride varnishes include.⁹

1. Sodium Fluoride (NaF) Varnish

2. Acidulated Phosphate Fluoride (APF) Varnish
3. Amine Fluoride Varnish
4. Stannous Fluoride Varnish

Each type of fluoride varnish has distinct properties, including fluoride concentration, pH level, and mechanisms of action. Understanding these characteristics is essential to evaluating their effectiveness in preventing enamel demineralization adjacent to orthodontic brackets.

Sodium Fluoride Varnish

Sodium fluoride (NaF) varnish is one of the most commonly used fluoride varnishes in both general dentistry and orthodontics. It typically contains a fluoride concentration of 5% (22,600 ppm). The varnish is applied to the teeth and forms a thin film that adheres to the enamel, allowing for the slow release of fluoride over an extended period.⁵

Research has shown that sodium fluoride varnish can effectively prevent enamel demineralization around orthodontic brackets. In a study by Challa et al. (2018), the application of NaF varnish significantly reduced the development of white spot lesions in patients undergoing fixed orthodontic treatment. The fluoride varnish was applied every 3 to 6 months,

and the results demonstrated a significant decrease in the incidence of enamel demineralization compared to control groups who did not receive fluoride treatment.¹ NaF varnish works by releasing fluoride ions that integrate into the enamel structure, forming fluorapatite crystals. This process helps prevent the dissolution of enamel minerals, thus reducing the risk of demineralization. Furthermore, the varnish provides a sustained fluoride release, offering ongoing protection even after the initial application.

Acidulated Phosphate Fluoride (APF) Varnish

Acidulated phosphate fluoride (APF)

varnish is another commonly used fluoride treatment. APF varnishes contain fluoride concentrations of 1.23%, which is lower than that of NaF varnishes. The acidity of APF varnishes, with a pH between 3.5 and 4.5, allows for better penetration of fluoride into the enamel structure, making it effective in preventing demineralization.¹⁰ Despite its advantages, the acidic nature of APF varnishes can be problematic for patients with orthodontic appliances. The acidity may interact with the metal components of the brackets and wires, potentially leading to corrosion.

Furthermore, the low pH may cause the varnish to be less effective on enamel that has already undergone early stages of demineralization. A study by Priya et al. (2019) compared the effectiveness of APF varnish and NaF varnish in orthodontic patients. The results showed that both varnishes were effective in reducing enamel demineralization, but NaF varnish had a slightly higher success rate in preventing the formation of white spot lesions. This suggests that, while APF varnish is effective, it may not be the optimal choice for patients with fixed orthodontic appliances due to potential compatibility issues with metal components.²

Amine Fluoride Varnish

Amine fluoride varnish is a newer formulation that combines fluoride with amines, which are organic compounds. This varnish has shown promise in preventing enamel demineralization due to its unique mechanism of action. Amine fluoride varnish adheres to the enamel surface, forming a more stable fluoride-rich layer that is resistant to acidic dissolution. Research conducted by Mandava et al. (2020) indicated that amine fluoride varnish is highly effective in preventing enamel demineralization, particularly when used in conjunction with orthodontic treatment. The study found that

amine fluoride varnish had superior remineralization potential compared to other fluoride varnishes, with a significant reduction in white spot lesions around orthodontic brackets.³ The unique properties of amine fluoride varnish make it a strong candidate for orthodontic patients. Its ability to create a stable and protective fluoride layer on enamel enhances its potential to prevent demineralization and promote remineralization during orthodontic treatment.

Stannous Fluoride Varnish

Stannous fluoride varnish contains tin fluoride (SnF_2) and is known for its strong antibacterial properties. The tin ions in stannous fluoride have been shown to inhibit bacterial metabolism, reducing the formation of acids that contribute to enamel demineralization. Additionally, stannous fluoride helps to form a protective layer on the enamel surface, reducing the risk of demineralization. A study by Beltrán et al. (2021) assessed the effectiveness of stannous fluoride varnish in preventing enamel demineralization around orthodontic brackets. The findings revealed that stannous fluoride varnish was highly effective in reducing plaque accumulation and

white spot lesions compared to sodium fluoride varnish. The study also noted that stannous fluoride varnish provided a longer-lasting effect, making it an ideal choice for patients undergoing orthodontic treatment.⁴ The antibacterial properties of stannous fluoride varnish are particularly advantageous for orthodontic patients, as they help reduce plaque formation around the brackets, thereby preventing the initiation of enamel demineralization.

Comparing the Effectiveness of Different Fluoride Varnishes

The effectiveness of different fluoride varnishes in preventing enamel demineralization adjacent to orthodontic brackets depends on several factors, including fluoride concentration, varnish composition, and patient compliance. Studies comparing the various types of fluoride varnishes have shown mixed results. However, the general consensus is that all fluoride varnishes, when applied correctly, are effective in reducing the incidence of white spot lesions and enamel demineralization.¹¹ In terms of clinical outcomes, sodium fluoride varnish tends to be the most widely recommended option due to its established efficacy and safety profile. However, amine fluoride varnish

has also shown promising results, particularly in its ability to enhance enamel remineralization.

Stannous fluoride varnish, with its additional antibacterial properties, may be beneficial for patients with high plaque accumulation, while APF varnish remains a viable option for certain cases, despite its potential drawbacks.⁶

Conclusion

Enamel demineralization adjacent to orthodontic brackets is a common and concerning issue during orthodontic treatment. Fluoride varnishes provide an effective means of preventing this demineralization by promoting remineralization and inhibiting plaque formation. While several types of fluoride varnishes are available, including sodium fluoride, acidulated phosphate fluoride, amine fluoride, and stannous fluoride, each has its unique advantages and limitations. Sodium fluoride varnish remains the most commonly used due to its proven effectiveness and safety. However, amine fluoride varnish, with its enhanced remineralization potential, and stannous fluoride varnish, with its antibacterial properties, also show great promise in preventing enamel demineralization in orthodontic patients. The choice of varnish should be based on individual patient needs,

considering factors such as plaque accumulation, risk of demineralization, and patient compliance.

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Midpalatal Suture Changes Following MARPE: Insights into Bone Remodeling and Healing Patterns

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Abstract

Miniscrew-assisted rapid palatal expansion (MARPE) has emerged as an effective technique for managing maxillary transverse deficiency, particularly in adolescents and adults where conventional rapid palatal expansion (RPE) may be less effective. By utilizing skeletal anchorage, MARPE facilitates maxillary expansion with minimal dental side effects. The midpalatal suture undergoes distinct morphological changes throughout growth, and its fusion varies significantly with age and individual factors. Post-MARPE healing involves bone regeneration through progressive mineralization, forming new bone structures within the expanded suture. Cone-beam computed tomography (CBCT) effectively monitors these changes. Research indicates that while bone density decreases initially, most adult patients show significant bone repair within 16 months post-treatment. MARPE has proven to be a reliable, non-surgical alternative for expanding the maxilla in mature patients, achieving substantial skeletal recovery with appropriate retention protocols.

Keywords: *Miniscrew-assisted rapid palatal expansion, Maxillary transverse deficiency, Midpalatal suture, Bone mineralization*

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Introduction

Maxillary transverse deficiency is a common form of malocclusion, with an incidence rate of approximately 21% in children and 10% in adults. This condition is often associated with various dental and skeletal issues, including unilateral or bilateral posterior crossbite, dental crowding, a high-arched palate, and a narrow nasal cavity. Such structural anomalies can contribute to functional complications such as masticatory and pronunciation disorders, as well as jaw dysfunction. Consequently, maxillary transverse deficiency can significantly impact oral health, maxillofacial function, and facial aesthetics.

The midpalatal suture (MPS) split has been recognized as an effective method for treating maxillary constriction and moderate maxillary crowding . This technique has demonstrated success in expanding the maxillary arch, particularly in younger patients.

Conventional rapid palatal expansion (RPE) remains a widely used method; however, its efficacy tends to decrease with advancing age, limiting its ability to achieve satisfactory maxillary transverse separation.

More recently, miniscrew-assisted rapid palatal expansion (MARPE) has emerged

as an innovative technique that extends the age limit for successful MPS splitting. By incorporating skeletal anchorage, MARPE enables effective treatment of maxillary constriction even in mature patients, offering a viable alternative when conventional RPE may be less effective.

The effectiveness of rapid maxillary expansion in producing skeletal or dentoalveolar changes is closely associated with the stage of skeletal maturation of the palatal suture. Optimal treatment timing for transverse deficiencies is generally recommended during early developmental stages, ideally before or around the peak skeletal growth velocity . However, the timing of skeletal maturation varies significantly among individuals , as the fusion of the palatal suture shows poor correlation with chronological age and sex. This variability presents a challenge in determining the most appropriate timing for intervention.

Midpalatal suture

The midpalatal suture undergoes distinct morphological changes throughout growth, significantly influencing its response to expansion treatments . Initially, during the infantile period, the suture presents as broad and Y-shaped in frontal sections, as described by Melsen . Over time, these structural changes impact the suture's

adaptability, playing a crucial role in the effectiveness of interventions such as rapid maxillary expansion (RME) and miniscrew-assisted rapid palatal expansion (MARPE). The midpalatal suture is classified as an end-to-end type of suture, further contributing to its unique developmental characteristics.

The midpalatal suture undergoes a distinct ossification process characterized by gradual changes in structure. This process begins with the development of bone spicules originating from the suture margins, alongside clusters of acellular and partially calcified tissue within the sutural gap. As the suture matures, these spicules become more numerous, forming irregular, scalloped patterns that are separated by connective tissue in certain regions.

Simultaneously, the suture exhibits increased interdigitation, adding to its structural complexity. Ossification typically starts in the posterior segment of the suture and progresses toward the anterior region. During this phase, cortical bone in the sutural ends is gradually resorbed, followed by the deposition of cancellous bone, marking the final stages of the ossification process.

The timing and progression of midpalatal suture fusion can vary significantly based on factors such as age and sex. Research by

Persson and Thilander observed suture fusion in individuals between 15 and 19 years of age. However, some patients as old as 27, 32, 54, and even 71 years have shown no signs of midpalatal suture fusion. These findings highlight that the fusion process is not strictly dependent on chronological age, particularly in young adults.

Due to this variability, Revelo and Fishman recommended that clinicians assess midpalatal suture morphology individually using occlusal radiographs before initiating rapid maxillary expansion (RME). However, occlusal radiographs have limitations, as overlying structures like the vomer and external nasal anatomy can obscure the midpalatal area, potentially leading to misinterpretation of suture fusion status. Cone-beam computed tomography (CBCT) has emerged as a superior diagnostic tool for evaluating midpalatal suture morphology. CBCT offers three-dimensional imaging with minimal superimposition of adjacent structures, improved accessibility, lower radiation exposure compared to traditional medical CT scans, and relatively low cost.



Figure 1: Schematic drawing of the maturation stages observed in the midpalatal suture

stage A - the midpalatal suture is almost a straight high-density sutural line with no or little interdigitation.

stage B - the midpalatal suture assumes an irregular shape and appears as a scalloped high-density line. Patients at stage B can also have some small areas where 2 parallel, scalloped, high-density lines close to each other and separated by small low-density spaces are seen.

stage C - the midpalatal suture appears as 2 parallel, scalloped, high-density lines that are close to each other, separated by small low-density spaces in the maxillary and palatine bones (between the incisive foramen and the palatino-maxillary suture and posterior to the palatino-maxillary suture). The suture can be arranged in either a straight or an irregular pattern.

stage D, the fusion of the midpalatal suture has occurred in the palatine bone, with maturation progressing from posterior to anterior. In the palatine bone, the midpalatal suture cannot be visualized at this stage, and the parasutural bone density is increased (high-density bone) compared with the density of the maxillary parasutural bone.

stage E - fusion of the midpalatal suture has occurred in the maxilla. The actual suture is not visible in at least a portion of the maxilla. The bone density is the same as in other regions of the palate.

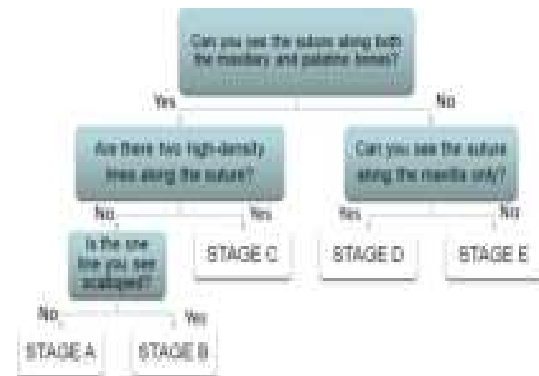


Figure 2: Decision tree for classification of the maturation stages of the midpalatal suture.

MARPE and midpalatal suture

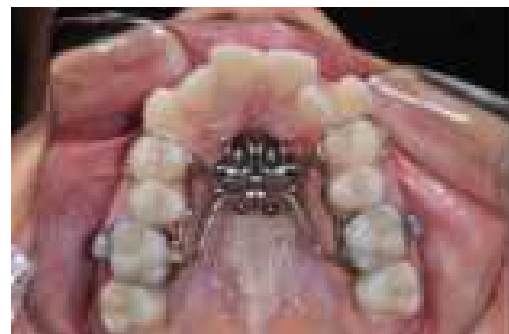


Figure 3: Expander used for MARPE

Miniscrew-assisted rapid palatal expander (MARPE) is an advanced orthodontic technique designed to manage maxillary transverse deficiencies, particularly in adolescents and adults where conventional rapid palatal expansion (RPE) may be less effective. By incorporating temporary anchorage devices (TADs), MARPE

enhances skeletal expansion while minimizing unwanted dental side effects.

Components of MARPE

MARPE appliances typically include:

- **Palatal expander framework:** A rigid expansion screw connected to the palatal vault.
- **Miniscrews (TADs):** Titanium screws inserted directly into the palatal bone to anchor the device.
- **Bands or acrylic support:** For additional stability in some designs.

Mechanism of Action

Unlike traditional RPE, which relies on dental anchorage, MARPE applies expansion forces directly to the skeletal structures via miniscrews. This technique:

- Enhances skeletal expansion with minimal dental tipping.
- Reduces the risk of periodontal damage and alveolar bone bending.
- Provides improved stability, especially in mature patients with higher suture resistance.

Indications for MARPE

MARPE is recommended for:

- **Adolescents and adults** with maxillary transverse deficiency.

- Patients with partially or fully fused midpalatal sutures.
- Individuals requiring non-surgical expansion with minimal dental side effects.
- Cases involving posterior crossbite, dental crowding, or narrow nasal airways.

Contraindications

MARPE may be less suitable for:

- Patients with extremely dense bone or complete midpalatal suture fusion.
- Those with severe periodontal issues or insufficient palatal bone thickness.

Advantages of MARPE

- Expands the maxillary arch effectively in older patients.
- Minimizes dental tipping and root resorption.
- Enhances airway volume, improving nasal breathing.
- Provides a non-surgical alternative for certain cases previously requiring surgery.

Studies have shown MARPE to be highly effective in achieving significant skeletal expansion with minimal dental side effects. It has demonstrated success

in treating young adults, expanding treatment possibilities for non-surgical correction of maxillary constriction.

Bone Regeneration and Mineralization Process

After MARPE-induced expansion, the midpalatal suture undergoes a complex remodeling process that involves new bone formation, mineral deposition, and eventual suture stabilization. The sequence of mineralization typically follows these stages:

1. **Initial Separation:** The midpalatal suture widens during MARPE activation, creating a radiolucent gap filled with fibrous connective tissue and blood vessels.
2. **Early Healing Phase:** Within the first few weeks post-expansion, osteoblast activity leads to the formation of new bone spicules extending from the suture margins.
3. **Progressive Mineralization:** Over time, these spicules increase in density and connectivity, filling the previously expanded sutural gap with woven bone.
4. **Mature Remodeling:** Over the following months, the woven bone transitions into organized lamellar

bone, enhancing suture stability and strength.

Factors Influencing Mineralization

Several factors influence the rate and quality of midpalatal suture mineralization post-MARPE, including:

- **Patient Age:** Younger patients typically demonstrate faster mineralization due to higher osteogenic potential.
- **Suture Maturation:** The degree of initial suture ossification affects the remodeling response.
- **Activation Protocol:** Gradual expansion with optimal retention time supports enhanced mineral deposition.
- **CBCT Analysis:** Cone-beam computed tomography (CBCT) effectively monitors changes in mineral density and suture morphology during healing.

Evidence from Recent Studies

Research has demonstrated that MARPE can achieve substantial skeletal expansion even in mature patients. Studies utilizing CBCT imaging have documented the following:

- Increased radiodensity in the expanded suture region, indicating progressive mineralization.
- Formation of interdigitated bone bridges, reinforcing suture stability.
- Enhanced nasal cavity width, suggesting broader skeletal changes linked to mineralization.



scores 1 to 3 for midpalatal bone repair after MARPE. A Score 1: incomplete bone repair in the midpalatal suture covering less than 50% of the hard palate; B Score 2: incomplete bone formation in the midpalatal suture with more than 50% of the hard palate demonstrating bone repair; C Score 3: complete repair of the midpalatal region extending from the anterior to the posterior region of the hard palate

Conclusion

Research has shown that midpalatal suture (MPS) repair occurs naturally in growing patients after conventional rapid palatal expansion (RPE). However, differences in the timing and pattern of MPS repair are expected when comparing younger individuals to adult patients.

A study investigating MPS repair following miniscrew-assisted rapid palatal expansion (MARPE) in adult patients highlighted key findings regarding bone density and healing patterns. Results indicated that bone density decreased after the retention period when compared to pre-expansion levels. Additionally, while most adult patients exhibited incomplete suture repair 16 months post-treatment, a significant portion (80.95%) demonstrated adequate bone regeneration covering more than half of the hard palate's extension.

These findings suggest that while MPS repair may be slower and less complete in adults, MARPE can still achieve substantial skeletal recovery with appropriate retention protocols and follow-up care.

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