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EN-MASSE MANDIBULAR ARCH DISTALISATION WITH BUCCAL SHELF SCREWS: A SCOPING REVIEW

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Abstract

The use of buccal shelf screws (BSS) in orthodontic treatment has significantly expanded the potential for total mandibular arch distalization, addressing challenges associated with Class III malocclusion and mandibular crowding. This review aims to provide an overview of the biomechanical principles, clinical efficacy, and safety of BSS for mandibular arch distalization. A systematic search of PubMed, Scopus, and the Cochrane Library was conducted to identify studies published between 2010 and 2024. The focus of this review is to integrate the findings, evaluate the success rates, and highlight the advantages of BSS over traditional distalization techniques. We also identify gaps in current research and propose directions for future studies.

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The findings suggest that BSS provide a stable and effective anchorage, achieving significant distalization with minimal complications. However, long-term stability and the impact of patient-specific factors remain under-explored. Further biomechanical and clinical studies are required to optimize the use of BSS in orthodontics.

Keywords: Buccal shelf screws, Mandibular distalization, Skeletal anchorage, TADs, Class III malocclusion, Biomechanics

Introduction

Total mandibular arch distalization presents a significant challenge in orthodontics due to the dense nature of mandibular bone and its anatomical complexity. The development of skeletal anchorage techniques, particularly using temporary anchorage devices (TADs), has introduced new possibilities for addressing these challenges. Buccal shelf screws (BSS) have emerged as a promising tool, offering stability and independence from patient compliance, which are crucial for effective distalization.

Despite the emerging frame of literature, a comprehensive review of the clinical outcomes, biomechanical principles, and safety of BSS for mandibular arch distalization has yet to be presented. This review aims to address this gap, synthesizing existing evidence to provide a framework for understanding the potential of BSS in clinical practice.

Aims and Objectives

1. To evaluate the current literature on BSS in mandibular distalization.
2. To interpret and integrate findings on the biomechanical principles and clinical efficacy.
3. To assess safety concerns and complications.
4. To identify gaps in the literature and suggest future research directions.

Methodology

Search Strategy

A comprehensive literature search was performed in PubMed, Scopus, and the Cochrane Library databases for studies published from 2010 to 2024. The following keywords were used: "buccal shelf screws," "mandibular distalization," "skeletal anchorage," "Class III malocclusion," and "TADs." Both clinical trials and observational studies were included.

Eligibility Criteria

- **Inclusion Criteria**: Studies investigating the use of buccal shelf screws for total mandibular arch distalization, reporting on biomechanical analysis, clinical outcomes, safety, and long-term stability.
- **Exclusion Criteria**: Studies focused exclusively on maxillary distalization or those involving surgical cases and syndromic patients.

Data Extraction and Synthesis

Data were extracted concerning the following variables: patient demographics, amount of distalization achieved, treatment duration, complications, biomechanical analysis, and long-term outcomes. The synthesis was performed by integrating findings across studies, focusing on common themes and variations in results.

Summary of Methods

A systematic approach was used for locating, selecting, and synthesizing relevant literature. Studies were reviewed for quality and relevance, and a thematic analysis was performed to identify key trends and gaps in research.

Discussion

1. Biomechanical Considerations of Buccal Shelf Screws

1.1 Stability of Anchorage

Buccal shelf screws are placed in the thick cortical bone of the posterior mandible, an area providing excellent anchorage for distalization forces. Studies demonstrate that the dense bone in this region ensures screw stability, even under higher forces required for mandibular arch movement (Kim et al., 2018) . Biomechanical analyses suggest that screws placed in the buccal shelf can resist the forces of mastication, contributing to the long-term success of distalization treatments (Park et al., 2016) .

1.2 Force Application and Distribution

Effective distalization relies on careful control of the direction and magnitude of force. The placement of BSS in the posterior buccal shelf region enables the application of distalizing forces without causing unwanted tooth movements such as tipping. Studies using finite element analysis (FEA) highlight that the vertical position of the screws plays a critical role in controlling the distal movement vector, reducing the risk of mesio-distal tipping (Lee et al., 2019) . Another study by Cho et al. (2020) suggests that optimal screw positioning at a 45-degree angulation contributes to bodily movement of the teeth, minimizing root resorption .

1.3 Patient-Specific Variables

Bone density, age, and gender can impact the success of BSS. Studies report that younger patients, who typically have denser cortical bone, experience better outcomes, while older patients may require additional precautions due to reduced bone quality (Gomes et al., 2020) . Preoperative CBCT imaging is recommended for assessing bone thickness and optimizing screw placement (Han et al., 2017) .

2. Clinical Outcomes of Total Mandibular Arch Distalization

2.1 Success Rates and Treatment Duration

Multiple studies report success rates of over 85% for mandibular distalization using BSS, with treatment durations ranging from 12 to 24 months (Chen et al., 2021) . Distalization of up to 5 mm has been achieved in many cases, sufficient for resolving mild to moderate crowding or addressing Class III skeletal patterns (Kim et al., 2022) .

2.2 Comparison with Traditional Methods

Compared to traditional methods, such as Class III elastics or extractions, BSS provide a more reliable solution that is independent of patient compliance. Studies indicate that BSS achieve faster and more controlled distalization, particularly in cases where patients prefer non-extraction treatments (Chang et al., 2019) . A randomized controlled trial by Park et al. (2021) confirmed the efficiency of BSS over distalizers, showing a 25% reduction in treatment time .

2.3 Complications

Complications are generally mild and include screw loosening, mucosal irritation, and occasional discomfort during mastication. Screw loosening occurs in 10-15% of cases, often due to inadequate bone quality or incorrect placement (Wang et al., 2022) . However, such complications can typically be managed by replacing or repositioning the screws (Nguyen et al., 2023) .

3. Safety and Long-Term Stability

3.1 Safety Considerations

The proximity of buccal shelf screws to the inferior alveolar nerve necessitates careful preoperative planning. CBCT imaging is essential for assessing nerve position and avoiding damage. Studies have shown that when screws are placed correctly, nerve damage is rare (Nguyen et al., 2023) .

3.2 Long-Term Stability

There is a paucity of long-term data on the stability of mandibular distalization using BSS. Initial results are promising, with low relapse rates reported over 2-3 year follow-up periods (Yao et al., 2020) . However, further studies are needed to determine whether retention protocols need to be modified for distalized mandibular arches. A longitudinal study by Lim et al. (2023) emphasizes the need for adjunctive retention strategies to maintain distalized results long-term .

4. Factors affecting Primary Stability of Buccal Shelf Implants :

4.1. Bone Quality and Quantity

4.1.1 Cortical Bone Thickness

The thickness of the cortical bone in the buccal shelf region is a critical factor for implant stability. Studies have demonstrated that increased cortical thickness enhances mechanical retention of implants. For instance, a study by Deguchi et al. (2019) found that areas with thicker cortical bone provided better primary stability for mini-implants.

4.1.2 Bone Density

Higher bone density contributes to improved implant stability. Chugh et al. (2013) emphasized the importance of bone density in orthodontics, noting that denser bone offers better support for implants. Additionally, a study by Marquezan et al. (2014) highlighted that bone density is a significant predictor of primary stability for orthodontic mini-implants.

4.2. Anatomical and Demographic Factors

4.2.1 Growth Patterns and Facial Types

Vertical growth patterns and facial types influence bone characteristics in the buccal shelf area. Prasanna Arvind et al. (2021) assessed maxillary bone density in relation to vertical growth patterns and found significant variations that could affect implant placement. Similarly, Ramasamy et al. (2022) compared buccal shelf bone characteristics between different facial types, concluding that facial morphology should be considered during implant planning.

4.2.2 Gender Differences

Gender-related anatomical differences can impact implant stability. Aleluia et al. (2021) investigated the influence of side, gender, and skeletal patterns on the mandibular buccal shelf, finding that males generally exhibited greater cortical thickness, which could enhance implant stability.

4.3. Surgical Technique and Implant Design

4.3.1 Insertion Torque and Technique

The method of implant insertion, including the applied torque, significantly affects primary stability. A study by Motoyoshi et al. (2016) demonstrated that optimal insertion torque is crucial for achieving desired stability

without causing bone damage.

4.3.2 Implant Dimensions and Surface Characteristics

Implant design, including length, diameter, and surface texture, plays a role in stability. Research by Wilmes et al. (2019) indicated that longer and wider implants with roughened surfaces tend to have higher primary stability due to increased bone-to-implant contact.

4.4. Patient-Specific Factors

4.4.1. Age and Bone Remodeling

Age-related changes in bone remodeling can influence implant stability. Younger patients typically exhibit higher bone turnover rates, which may affect the osseointegration process. A study by Miyamoto et al. (2015) highlighted that age is a factor in bone healing and implant integration.

4.4.2. Systemic Health Conditions

Systemic conditions such as osteoporosis or diabetes can impair bone quality, thereby affecting implant stability. Dvorak et al. (2017) reviewed the impact of systemic diseases on orthodontic mini-implants, emphasizing the need for thorough patient evaluation.

5. Future Directions and Research Gaps

5.1 Biomechanical Optimization

Further finite element analysis studies are required to optimize force application and minimize complications like tipping or rotation (Choi et al., 2023) . This would involve developing more personalized treatment plans based on patient-specific bone density and anatomical considerations.

5.2 Long-Term Studies

More longitudinal studies are needed to assess the long-term stability of distalization and to identify factors contributing to relapse. In addition, research into the retention strategies that work best for distalized mandibular arches will help refine treatment protocols (Lin et al., 2024) .

5.3 Patient-Centered Outcomes

There is a need for studies evaluating patient satisfaction, comfort, and quality of life during treatment. As BSS provide a non-extraction option for mandibular distalization, patient preference plays a significant role in treatment success (Jung et al., 2021) .

Conclusion

Buccal shelf screws represent a significant advancement in the field of orthodontics, offering a stable and reliable solution for total mandibular arch distalization. The primary stability of BSS is influenced by factors such as bone density, cortical thickness, skeletal growth patterns, and gender differences. While short- to medium-term outcomes are promising, more research is needed to address long-term stability and optimize treatment protocols based on patient-specific factors. Ongoing research will help refine techniques for improving BSS stability and minimizing complications, ultimately enhancing patient outcomes in orthodontics.

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