



“Clinical Comparative Analysis of TAD-Augmented and Conventional Orthodontic Treatments in Skeletal Open Bite Correction: An Original Research Study”

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ABSTRACT:

Aim: This study aims to compare the clinical analysis evaluating the effectiveness of orthodontic correction by Conventional Mechanotherapies and TAD-Augmented in patients diagnosed with skeletal open bite.

Materials and Methods: This study assessed 50 patients with anterior open bite (AOB) seeking corrective treatment, narrowing down to 40 who met specific skeletal criteria based on cephalometric analysis. Key criteria included an increased mandibular plane angle, enlarged lower anterior facial height, and a dolicofacial growth pattern. AOB was defined by minimal vertical overlap of front teeth, resulting in a negative overbite of less than 1 mm. Exclusions involved cases related to tooth under-eruption without skeletal issues, decreased incisal display, chronic medical conditions, and significant dental crowding. Informed consent was obtained, and the final cohort received. Patients were divided into two groups: Group 1 received open bite correction with conventional mechanotherapies, while Group 2 underwent TAD-Augmented open bite correction. Follow-ups at one, two, and three years post-treatment utilised cone beam computed tomography to evaluate outcomes, including overbite correction, occlusion, aesthetics, recovery profiles, treatment duration, and patient satisfaction.

Statistical Analysis and Results: This study analysed a cohort of 40 patients aged 7 to 30 years, consisting of 24 males and 16 females, divided into two groups based on treatment.



Group 1 included 20 patients who received only orthodontic treatment aimed at dental alignment. Group 2 comprised 20 patients who underwent TAD-Assisted dental and skeletal issues related to anterior open bite. Outcomes for Group 1 were monitored over one year, with 7 patients showing no significant changes. In Group 2, 2 patients exhibited no improvement during the same period. A two-year follow-up for Group 1 indicated that 6 patients remained unchanged, while in Group 2, only 1 patient showed no changes. After three years, 5 patients in Group 1 had not improved, but notably, no patients in Group 2 showed any changes. A comparative analysis across groups using one-way ANOVA, presented in Table 8 provides insights into the effectiveness of orthodontic treatment alone versus the combination of surgery and orthodontics for addressing anterior open bite issues.

Conclusion: This study found that TAD assisted approach yields better results for severe cases, enhancing occlusion and facial aesthetics, while conventional orthodontics is more effective for mild to moderate open bites. The integrated method provides faster treatment and improved long-term stability by repositioning the jawbones, addressing skeletal discrepancies, whereas orthodontic treatment by conventional mechanotherapies mainly involves dental movement, which may be less stable with significant skeletal malalignment.

Introduction

An open bite is a dental condition marked by a noticeable vertical gap between maxillary and mandibular anterior teeth when the mouth is closed. An open bite can impact not only the anterior teeth but also the posterior segments of the dental arch, leading to complications in overall oral health and function.¹ The origins of open bites are diverse and complex, stemming from a variety of skeletal structures, dental configurations, and habitual behaviors.² These factors can interact in intricate ways, resulting in this specific type of malocclusion that affects individuals differently, potentially influencing speech, aesthetics, and general oral well-being. Understanding the underlying causes is crucial for effective treatment and resolution of this condition. Open bites can be categorized according to skeletal structure.³⁻⁵ They are divided into two main variants: skeletal and dental open bites. Skeletal open bites typically result from underlying jaw growth discrepancies, while dental open bites are primarily due to the positioning of the teeth themselves. Within these categories, open bites can be further classified as anterior-where there is a loss of contact between the incisors-and posterior, which involves a failure of the molars to contact properly. Lateral open bites can also occur; resulting in occlusal discrepancies that predominantly affect one side of the dental arch.⁶ The etiology of open bites is complex and often involves multiple contributing factors. One of the most common

causes of anterior open bites is associated with parafunctional habits, such as thumb sucking or prolonged use of pacifiers, particularly in children. These habits can lead to the anterior teeth being pushed forward and the development of an open bite.⁷ Furthermore, excessive vertical facial development, which may be due to genetic predisposition or environmental influences, can create skeletal open bites by altering jaw relationships and overall facial height.⁸ To diagnose an open bite, a comprehensive clinical evaluation is essential. This includes a detailed patient history, a clinical examination of occlusion, and an assessment of dental and skeletal relationships. Advanced diagnostic tools, such as cephalometric analysis, which provides measurements of the skull and its relationship with dental structures, as well as radiographic imaging, are pivotal in forming an accurate diagnosis.⁹ Cone Beam Computed Tomography (CBCT) is particularly beneficial for visualizing intricate jaw structures, allowing for a thorough assessment of the anatomy involved. Radiographic evaluations can identify pertinent growth patterns, with cephalometric views detailing variations in facial height, and panoramic radiographs offering a broad perspective on the entire dentition.^{10,11} The treatment of open bites is tailored to the severity of the malocclusion, the patient's age, and the underlying cause. For more severe cases, orthognathic surgery may be indicated, which typically involves a comprehensive treatment approach



combining pre-surgical orthodontic preparation with postoperative follow-up care. Nonsurgical options may focus on orthodontic treatments, such as molar intrusion techniques, to achieve proper occlusal alignment with the help of temporary anchorage devices. Specific elastics can be employed to correct the dental positions, aiming for improved bite alignment. Additionally, speech therapy may be beneficial, particularly in young patients, to address any resultant speech issues stemming from the malocclusion.¹² Open bite is one of the most challenging malocclusions in orthodontics due to the difficulty of achieving long-term stability. As a result, skeletal anchorage devices such as miniplates and miniscrews are currently widely used in orthodontics for their ability to provide reliable anchorage throughout treatment. These devices allow for the correction of skeletal AOB by facilitating molar intrusion, which is more effective and less invasive than anterior tooth extrusion, and promotes a counterclockwise mandibular rotation that contributes to bite closure.¹³ Although orthognathic surgery has traditionally been the treatment of choice for skeletal anterior open bite, the use of miniplates and miniscrews has proven to be a less invasive alternative with lower risk and faster recovery. So, the aim of this study is to compare the clinical analysis evaluating the effectiveness of orthodontic correction with temporary anchorage devices versus orthodontic treatment alone in patients diagnosed with skeletal open bite

Materials and Methods

This study commenced with a comprehensive clinical assessment and radiographic diagnosis involving a cohort of 50 patients who exhibited anterior open bite (AOB) and expressed interest in undergoing corrective treatment. After thorough evaluation, 40 patients were identified as meeting the criteria necessary for inclusion in the treatment selection process. This cohort consisted of a balanced representation, with both male and female participants contributing to the study's demographic diversity. In terms of inclusion criteria, the study targeted specific skeletal discrepancies as confirmed by cephalometric analysis. These discrepancies included a significantly increased mandibular plane angle, particularly evidenced by an SN/GoMe angle exceeding 37 degrees, an augmentation of lower anterior facial height, a dolicofacial growth pattern, and an elevated B-angle, which denotes the angular relationship between

the maxillary and mandibular planes. The specific characterization of anterior open bite (AOB) employed in this study was defined by minimal vertical overlap between the upper and lower incisor teeth, resulting in a negative overbite measured at less than 0.5 mm or 1 mm, indicating a clear lack of contact between these teeth when the jaws are occluded. Several exclusion factors were applied to refine the patient selection further. Cases of open bite caused by under-eruption of anterior teeth without underlying skeletal contributions were excluded, as were patients presenting with decreased incisal display or a reversed smile arc that would necessitate incisor extrusion. Additionally, individuals with medical conditions that could complicate treatment, those on chronic medications that might hinder tooth movement, and patients exhibiting moderate to severe dental crowding that would lead to the necessity of tooth extraction were not included in the study. Furthermore, patients with systemic issues that could potentially impact the temporomandibular joints were also excluded. Informed consent was meticulously obtained from all participants before proceeding with any treatment intervention. Ultimately, the final cohort consisted of 40 patients who adhered strictly to the defined inclusion and exclusion criteria. Significantly, the segmental upper arch orthodontic preparation was undertaken by the orthodontic specialist (referred to here as EG), ensuring a tailored approach to each patient's unique dental architecture. However, there might be other, less-invasive treatment options not requiring orthognathic surgery. If it is possible to orthodontically intrude posterior teeth, the accompanying changes in occlusal plane, mandibular plane, lower anterior face height, and anterior dental overbite would close the patient's open bite. This can be accomplished by placing an implant or a miniplate and attachment to intrude the posterior teeth. So, this study population was categorized into two distinct groups for analytical purposes. Group 1 was composed of 20 patients who underwent orthodontic treatment exclusively, receiving interventions focused solely on dental alignment and occlusal improvement. In contrast, Group 2 included 20 patients who received a more comprehensive approach involving orthodontic correction with temporary anchorage devices, addressing not only dental alignment but also the underlying skeletal issues contributing to their anterior open bite. The treatment employed a pre-adjusted



edgewise system with an MBT prescription. 0.014” NiTi archwires were placed initially to achieve alignment and leveling. Upon achieving preliminary alignment, upper first premolars were extracted to facilitate space management. Post-extraction, segmental mechanics were introduced in the maxillary arch for controlled anterior retraction. This allowed for correction of maxillary incisor proclination and space closure using bilateral NiTi closed-coil springs. In the mandibular arch, after satisfactory alignment, a 0.017 × 0.025” stainless-steel continuous archwire was inserted for working and finishing stages. Posterior bite planes built in a centric relation and additional anchorage from TADs were taken by placing 2 buccal TADs bilaterally of 8mm in length and 1.3mm in diameter, and 2 palatal bilaterally of 6mm in length and 1.3mm in diameter to intrude the upper molars. The Bite planes was installed and was adjusted to obtain maximum bilateral contact with lower teeth. The patient was instructed to wear the appliance approximately 24 hours a day, including during meals. Once in 14 days check-ups were scheduled, in order to keep the appliance with the maximum contact between the Bite Block plane and lower teeth, as well as to motivate the patient. After

appliance removal, an adequate relation was observed between upper and lower teeth. The correction of this malocclusion was the result of counterclockwise rotation of the mandible, retroclination of incisors, intrusion of the molars. To evaluate the efficacy of the interventions systematically, follow-up assessments were conducted at one, two, and three years’ post-treatment, utilizing advanced imaging techniques such as cone beam computed tomography (CBCT). The evaluative measures employed included assessments of the stability of treatment results, overbite correction, functional outcomes pertaining to occlusion and mastication, aesthetic improvements observed in facial profile and smile, recovery profiles detailing the healing process, treatment duration, and a host of patient-related factors influencing satisfaction and overall outcomes. The primary objective of this study is to provide a comparative analysis of the clinical outcomes from orthodontic correction TAD augmented versus those achieved through orthodontic treatment alone in individuals diagnosed with skeletal anterior open bite. This comparison aims to enhance understanding of treatment efficacy and inform future practices in the management of this challenging dental condition.



Fig.1 Pre treatment-Open bite



Fig.2 Palatal and Buccal TADS for intrusion of molars for correction of open bite



Fig.3 Post Treatment- Corrected Open Bite

Statistical Analysis and Results

In this study, we utilised SPSS software for our statistical analysis. SPSS version 29.0 is a robust tool designed for statistical computing and data analysis in the social sciences. To assess the significance of our findings, we employed the chi-square test, which is well-suited for examining differences in proportions among various groups. This approach enabled us to conduct a thorough and careful comparison of categorical data, ensuring that our results accurately represent the underlying trends and relationships within the dataset.

Results

This study focused on a carefully selected cohort of 40 patients, aged between 7 to 30 years, comprising 24 males and 16 females. Participants were divided into two distinct groups based on the type of treatment they received. A comprehensive overview of the age and gender demographics of the enrolled patients can be found in Table 1, while Graph 1 visually represents the demographic distribution and key characteristics pertinent to the patient population. Group 1 included 20 patients who underwent orthodontic treatment with conventional mechanotherapies exclusively, which was specifically targeted at achieving dental alignment and improving occlusal relationships. This group's treatment plan emphasized the correction of dental positioning without surgical intervention. Conversely, Group 2 consisted of 20 patients who received a more extensive treatment plan that included TAD-Augmented orthodontic correction. This comprehensive approach addressed not only the alignment of teeth but also rectified the underlying skeletal discrepancies that contributed to the patients' anterior open bite. Outcomes for Group 1 (N=20) were meticulously tracked over a

one-year follow-up period, as presented in Table 2. A statistical analysis utilizing the Pearson Chi-Square test indicated that there were no significant changes observed in 7 of the patients at the conclusion of this period, suggesting a plateau in improvement for these individuals. Table 3 illustrates the findings for Group 2 (N=20), which were similarly monitored for one year following their orthognathic surgery and orthodontic treatment. The analysis found that 2 patients within this group exhibited no changes over the same duration, also supporting the notion of limited further improvement in this subset during the initial year. Shifting focus to a longer-term evaluation, Table 4 revisits Group 1 patients after a two-year follow-up. The results revealed that 6 patients had shown no changes, as determined through the same statistical approach. Building on this, Table 5 outlines the outcomes for Group 2 participants (N=20) following two years of observation, where the statistical analysis again indicated that only 1 patient had not exhibited any changes. The longitudinal assessment continues in Table 6, which tracks Group 1 over a three-year period, showing that 5 patients remained unchanged according to the results from the Pearson Chi-Square test. In a notable contrast, Table 7 specifically highlights the outcomes for Group 2 patients after three years, indicating a positive result where no patients showed any signs of change during this extended assessment period. Finally, Table 8 provides a thorough comparative analysis across all assessed groups utilizing one-way ANOVA. This statistical framework allows for a broader understanding of the efficacy of the different treatment modalities employed, contributing valuable insights into the relative effectiveness of orthodontic treatment with conventional mechanotherapy versus TAD-Augmented orthodontic correction in addressing anterior open bite issues.



Table 1: Age & gender based statistical description of contributing patients

Age Group (Yrs)	Male	Female	Total	P value
7-10	3	3	6	0.02*
11-15	5	4	9	0.50
16-20	4	3	7	0.08
21-25	4	2	6	0.40
26-30	8	4	12	0.70
Total	24	16	40	*Significant

*p<0.05 significant

Graph 1: Patients demographic distribution and associated details

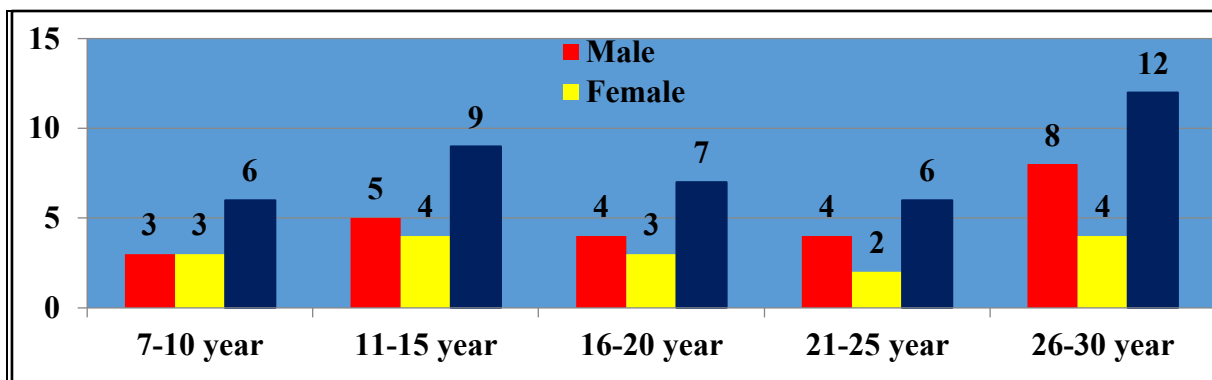


Table 2: Group 1 (N=20) patients underwent orthodontic treatment, and their progress was closely monitored over a follow-up period of one year. To analyse the significance of the findings from this study, a statistical evaluation was conducted using the Pearson Chi-Square test

Effectiveness parameters	N	Stat. Mean	Std. Dev.	Std. Error	95% CI	Pearson Chi-Square Value	df	p value
Stability	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Overbite correction	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Functional outcome	1	1.03	1.023	1.014	1.02	1.012	1.0	0.01*
Aesthetics	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Procedure and recovery	1	1.03	1.023	1.014	1.02	1.012	1.0	0.01*
Treatment duration	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*



Patient factors	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
No change	7	2.24	1.056	1.253	2.54	2.042	1.0	0.50
*p<0.05 significant								

Table 3: Group 2 (N=20) patients underwent TAD-Augmented orthodontic correction, and their progress was closely monitored over a follow-up period of one year. To analyze the significance of the findings from this study, a statistical evaluation was conducted using the Pearson Chi-Square test

Effectiveness parameters	n	Stat. Mean	Std. Dev.	Std. Error	95% CI	Pearson Chi-Square Value	df	p value
Stability	4	1.07	1.055	1.047	1.10	1.035	1.0	0.06
Overbite correction	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Functional outcome	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Aesthetics	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Procedure and recovery	1	1.03	1.023	1.014	1.02	1.012	1.0	0.01*
Treatment duration	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Patient factors	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
No change	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
*p<0.05 significant								

Table 4: Group 1 (N=20) patients underwent orthodontic treatment, and their progress was closely monitored over a follow-up period of two year. To analyze the significance of the findings from this study, a statistical evaluation was conducted using the Pearson Chi-Square test.

Effectiveness parameters	N	Stat. Mean	Std. Dev.	Std. Error	95% CI	Pearson Chi-Square Value	df	p value
Stability	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Overbite correction	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Functional outcome	1	1.03	1.023	1.014	1.02	1.012	1.0	0.01*
Aesthetics	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Procedure and	1	1.03	1.023	1.014	1.02	1.012	1.0	0.01*



recovery								
Treatment duration	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Patient factors	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
No change	6	2.17	1.046	1.240	2.44	2.032	1.0	0.30
*p<0.05 significant								

Table 5: Group 2 (N=20) patients underwent TAD-Augmented orthodontic correction, and their progress was closely monitored over a follow-up period of two year. To analyze the significance of the findings from this study, a statistical evaluation was conducted using the Pearson Chi-Square test

Effectiveness parameters	N	Stat. Mean	Std. Dev.	Std. Error	95% CI	Pearson Chi-Square Value	df	p value
Stability	5	1.10	1.066	1.074	1.21	1.045	1.0	0.09
Overbite correction	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Functional outcome	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Aesthetics	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Procedure and recovery	1	1.03	1.023	1.014	1.02	1.012	1.0	0.01*
Treatment duration	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Patient factors	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
No change	1	1.03	1.023	1.014	1.02	1.012	1.0	0.01*
*p<0.05 significant								

Table 6: Group 1 (N=20) patients underwent orthodontic treatment, and their progress was closely monitored over a follow-up period of three year. To analyze the significance of the findings from this study, a statistical evaluation was conducted using the Pearson Chi-Square test

Effectiveness parameters	N	Stat. Mean	Std. Dev.	Std. Error	95% CI	Pearson Chi-Square Value	df	p value
Stability	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Overbite correction	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Functional outcome	1	1.03	1.023	1.014	1.02	1.012	1.0	0.01*
Aesthetics	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Procedure and	1	1.03	1.023	1.014	1.02	1.012	1.0	0.01*



recovery								
Treatment duration	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Patient factors	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
No change	5	1.10	1.066	1.074	1.21	1.045	1.0	0.09
*p<0.05 significant								

Table 7: Group 2 (N=20) patients underwent TAD-Augmented orthodontic correction, and their progress was closely monitored over a follow-up period of three year. To analyze the significance of the findings from this study, a statistical evaluation was conducted using the Pearson Chi-Square test

Effectiveness parameters	N	Stat. Mean	Std. Dev.	Std. Error	95% CI	Pearson Chi-Square Value	df	p value
Stability	6	2.17	1.046	1.240	2.44	2.032	1.0	0.30
Overbite correction	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Functional outcome	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
Aesthetics	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Procedure and recovery	3	1.05	1.045	1.045	1.09	1.024	1.0	0.03*
Treatment duration	1	1.03	1.023	1.014	1.02	1.012	1.0	0.01*
Patient factors	2	1.04	1.043	1.043	1.08	1.022	1.0	0.02*
No change	0	-	-	-	-	-	-	-
*p<0.05 significant								

Table 8: Estimation amongst all studied groups using one-way ANOVA

Variables	Degree of Freedom	Sum of Squares Σ	Mean Sum of Squares $m\Sigma$	F	Level of Sig. (p)
Between Groups	4	1.260	2.464	1.4	0.01*
Within Groups	17	2.257	2.422		-
Cumulative	114.18	5.865	*p<0.05 significant		



Discussion

Anterior open bite is found in 17% of patients seeking orthodontic treatment; its overall prevalence ranges from 25% to 38%, depending on demographic factors.¹⁴ Lowe BF et al reviewed in their study that an open bite is a specific type of malocclusion characterised by a discernible interarch space between the maxillary (upper) and mandibular (lower) dental arches when the teeth are in occlusion.¹⁵ This dental condition can present itself in two primary forms: anterior open bite, which involves the incisors, and posterior open bite, which impacts the molars. The aetiology of open bites is multifactorial, encompassing a blend of genetic predispositions, environmental factors, and certain oral habits that can affect dental and skeletal alignment.¹⁶ Fields et al showed in their study that from genetic perspective, open bites can stem from hereditary skeletal dysmorphologies, which are physical irregularities in the structure of the skull and facial bones. These genetic predispositions can disrupt the normal spatial relationship between the maxilla and mandible. When the skeletal framework experiences such discrepancies, it can obstruct the ideal alignment of the dental arches, leading to the characteristic gaps seen in open bites.¹⁷ Lin LH et al included in their study that environmental influences play a crucial role, particularly during the formative years of paediatric development. Behaviours that are sustained over time, such as thumb sucking, tongue thrusting, and prolonged pacifier use, exert continuous biomechanical forces on the developing craniofacial structure.¹⁸ These habits can alter the natural growth patterns of the jaw and surrounding tissues, ultimately impacting dental alignment. Furthermore, atypical swallowing patterns can exacerbate existing dental occlusion issues, leading to more severe malocclusion. A comprehensive understanding of these factors is crucial for healthcare professionals to accurately diagnose the condition and implement targeted therapeutic interventions.^{19,20} Phi L et al reviewed in their study that the clinical diagnosis of an open bite requires a thorough evaluation process, which includes taking an extensive dental history to identify potential harmful habits that may have contributed to the malocclusion. Clinical assessments are often supplemented with diagnostic imaging techniques such as cephalometric radiography and cone-beam computed tomography (CBCT).²¹ These imaging

modalities are vital for differentiating between dental open bites, which are primarily caused by positional misalignments of teeth, and skeletal open bites, which involve underlying skeletal discrepancies that need to be addressed.²² Chen J et al included in their study that when it comes to managing open bites, treatment strategies must be individualised based on the severity of the condition and the root causes identified. For mild open bite cases, orthodontic treatments using fixed appliances like traditional braces or modern clear aligners may prove effective. These devices are designed to gradually shift the teeth into proper alignment, thus minimising the open bite.²³ However, in more severe cases where considerable skeletal discrepancies are present, surgical interventions may become necessary. However, there might be other, less-invasive treatment options not requiring orthognathic surgery. This can be accomplished by placing an implant or a miniplate and attachment to intrude the posterior teeth.²⁴ Kwon TG et al showed in their study that if left untreated, open bites can lead to significant functional impairments. Individuals may experience challenges with chewing, resulting in difficulties with nutrition and digestion. Speech disorders may also arise, impacting communication.²⁵ Thus, early diagnosis and timely intervention are crucial for achieving positive treatment outcomes. Proactive and comprehensive management not only enhances the aesthetic appeal of the smile but also contributes to improved overall occlusal function, fostering better health and well-being in the long term.²⁶

Conclusion

In this study, the authors conducted a clinical analysis to evaluate the efficacy of TAD-Augmented orthodontic treatment versus orthodontic treatment with conventional mechanotherapies for patients with skeletal open bite malocclusions. The findings indicated that TAD-Augmented orthodontic treatment yields superior outcomes for severe skeletal open bite cases, providing significant and stable improvements in both occlusion and facial aesthetics. In contrast, treatment with conventional mechanotherapies is more effective for mild to moderate open bites. The integrated approach facilitates faster treatment durations and enhances long-term stability by directly repositioning the jawbones, thereby addressing the fundamental skeletal discrepancies. In comparison, orthodontic treatment relies primarily on dental movement, which may prove



less stable in cases of pronounced skeletal malalignment. These findings underscore the necessity for further research to elucidate the underlying mechanisms and to refine clinical practices within the orthodontic field moving forward.

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