

HOW CLEAR ALIGNER PERFORMED IN TREATING CLASS I, II, III MALOCCLUSION? A RETROSPECTIVE STUDY

Mohammed Barashi¹

¹ Preventive Dentistry Department, Faculty of Dental Medicine, Umm Al-Qura University, Makkah, Saudi Arabia

Corresponding author: Mohammed Barashi mabarashi@uqu.edu.sa

ABSTRACT

Aim of the study: This research aims to evaluate the performance of clear aligners in treating Class I, Class II, and Class III malocclusion. **Materials and methods:** The study retrospectively assessed healthy adult patients treated orthodontically with clear aligners. Data analysis included descriptive statistics, chi-square tests, and regression analyses to assess the relationships between Angle's classifications, spacing or crowding measurements, and the need for treatment refinement. **Results:** Participants comprised a total of 115 individuals, including a female majority (87.0%; n=100). The data presents the distribution of cases according to the Angle classification among the participants. Class I cases comprise the majority at 57.4% (n=66), followed by Class II at 27.8% (n=32), and Class III at 14.8% (n=17). The coefficient is 0.64, suggesting that individuals in Class III have a mean spacing or crowding at the end of treatment that is significantly greater than those in Class I, with a statistically significant p-value (<0.01 ; 95% CI: 0.29, 0.99). **Conclusions:** This study indicates that clear aligners might be more effective for treating Class I malocclusion, while Class II and III cases require more adjustments. Further research is necessary to understand the long-term effects of clear aligners and to optimize treatment strategies for different types of malocclusions.

Key words: malocclusions, performance, accuracy, refinement, clear aligners

INTRODUCTION

Malocclusion refers to the improper alignment or relationship of teeth. It is a common dental issue that impacts both appearance and function. In 1899, Edward H. Angle introduced a classification system for malocclusion based on the positional relationship between the upper and lower first molars. This system categorizes malocclusions into classes: Class I, II, and III. Angle defined normal occlusion as the mesiobuccal cusp of the maxillary first molar aligning with the buccal groove of the mandibular first molar. In Class II malocclusion, the distobuccal cusp of the maxillary first molar aligns with the buccal groove of the mandibular molar. In contrast, in Class III malocclusion, the mesiobuccal cusp of the maxillary first molar occludes between the mandibular first and second molars (1,2).

Clear aligners represent a significant advancement in orthodontic treatment. Initially introduced in the 1980s as retainers, their potential for realigning teeth was quickly recognized (3). The introduction of Invisalign by Align Technology in 1998 revolutionized orthodontics by offering an aesthetically pleasing and comfortable alternative to traditional fixed appliances (4). Over the years, clear aligners have gained popularity due to their advantages in aesthetics, comfort, and improved periodontal health compared to fixed appliances. Studies have shown that clear aligners are associated with reduced prevalence and severity of apical root resorption, and better periodontal outcomes than fixed appliances (5-8). However, they may have limitations, such as less effective root control during the closure of extraction

spaces (9).

The predictability of tooth movement using clear aligners varies among different forms, ranging from 30 to 88% and it is evident that there is a difference between predicted and accurate tooth movements (10-14). The mean accuracy of Invisalign for all tooth movements was 50%, according to earlier research (10), and the accuracy of intrusion of the mandibular and maxillary central incisors was 46.6% and 44.7%, respectively (11). According to retrospective research, 70% of spaces are closed accurately (12). A prospective study with 31 people and 53 canines found that the average accuracy for canine rotation was 35.8% (13). Simon et al. observed high predictability (88%) of maxillary molar distalization movement (14).

Many malocclusions are now treated with clear aligners (1516), mainly because of advancements in aligner materials, auxiliaries, and attachments that enable sophisticated movements like torque or rotation (17, 18). This research aims to evaluate the performance of clear aligners in treating Class I, Class II, and Class III malocclusions.

MATERIALS AND METHODS

Patients treated orthodontically with clear aligners were selected retrospectively from one private clinic in Makkah, Saudi Arabia. The sample included healthy adult patients. Patients that needed extraction during their ortho treatment were excluded from the study. The convenient sample included 115 patients, and they were stratified based on Angle's classifications into Class I, II, and III. Demographic data like gender and age were collected. Several clinical variables were collected, including treatment length (less than 6 months or 6 months or more), type of

the arch (upper or lower), and severity of the case (mild, moderate, or severe). Furthermore, the cases were categorized into spacing ortho cases and crowding ortho cases; the amount of the crowding or the spacing before starting of the treatment was measured using millimetres (mm) by one orthodontist. Also, the need of the refinement at the end of the treatment was measured by the same orthodontist in mm. The iTero intraoral scanner (Align Technology Inc., San Jose, CA) was utilized, and the dental models were uploaded to ClinCheck Pro software (Align Technology Inc.). Pretreatment and anticipated posttreatment dental models were exported from ClinCheck. The pre-treatment spacing or crowding as well as the results achieved were measured individually for each dental arch.

Stata Version 18 (StataCorp, College Station, TX, USA) was used to analyse the data. Descriptive results for the demographic and clinical variables were reported by stratifying them using Angle's classifications. Both count and percentage were calculated, and a chi square test was used to assess the dependence of the demographic and clinical variables on the Angle's classifications. Furthermore, linear regression analysis of the association between Angle's classifications and the mean in spacing or crowding at the end of treatment and logistic regression analysis of the association between Angle's classifications and the need for refinement at the end of treatment were conducted. Beta coefficient and odds ratio were conducted for the linear regression and the logistic regression, respectively. Clinical significance was set at <0.05 . Ethical approval was granted by the Institutional Review Board of the College of Dentistry at Umm Al-Qura University. All data was protected and fully

de-identified to ensure confidentiality.

RESULTS

Table 1 shows a total of 115 individuals, with a female majority (87.0%; n=100). Among the participants, those under 30 years of age represent 53.9% (n=62), while 54.8% (n=63) of the participants had a treatment duration of six months or more. Regarding arch type, 53.0% (n=61) of the cases were in the lower arch, and 52.2% (n=60) were classified as spacing cases. In terms of severity, mild cases comprised 54.8% (n=63), followed by moderate cases at 31.3% (n=36). Additionally, 32.2% (n=37) of the cases required refinements after the end of treatment. The data presents the distribution of cases according to Angle's classification among the participants. Class I cases comprise the majority at 57.4% (n=66), followed by Class II at 27.8% (n=32), and Class III at 14.8% (n=17). Regarding gender, 46.7% of males are in Class I (n=7), while 59.0% of females are in Class I (n=59). In terms of age, 61.3% of individuals under 30 years are in Class I (n=38), whereas 52.8% of those aged 30 or more are in Class I (n=28). Treatment length indicates that 57.7% (n=30) of the cases that had treatment durations of less than six months are in Class I. In terms of arch type, 59.3% of the upper arch cases are in Class I (n=32) compared to the lower arch (55.7%; n=34). For case type, 70.0% of spacing cases fall under Class I (n=42), while 43.6% of crowding cases are in Class I (n=24). Regarding severity, 58.7% of mild cases are in Class I (n=37). Finally, 61.5% (n=48) of Class I cases did not require refinements, whereas 48.7% (n=18) of Class II cases needed refinements after treatment. Age and case type significantly influence Angle's classification, with p-values of 0.002 for age and 0.017 for case type, indicating a statistically significant association with the

classification.

Table 2 presents the results of a linear regression analysis examining the relationship between Angle's classifications of malocclusion and the mean spacing or crowding measured in millimetres at the end of treatment. The coefficient is 0.64, suggesting that individuals in Class III have a mean spacing or crowding at the end of treatment that is significantly greater than those in Class I, with a statistically significant p-value (<0.01 ; 95% CI: 0.29, 0.99). The results are adjusted for several factors: gender, age, the need for refinement at the end of the treatment, arch type, and whether the case involves crowding or spacing.

Table 3 presents the results of a logistic regression analysis examining the association between Angle's classifications of malocclusion and the need for refinement at the end of treatment. The adjusted odds ratio for Class II is 2.3, indicating that individuals in Class II are 2.3 times more likely to require refinement compared to those in Class I. The adjusted odds ratio for Class III is 1.3, suggesting that individuals in Class III are 1.3 times more likely to require refinement than those in Class I. However, the p-values for both adjusted odds ratios are above 0.05, indicating that these results are not statistically significant.

Table 4 presents the mean millimetres needed for refinements at the end of treatment across different Angle classifications. For Class I, males required an average of 2.5 mm (SD = 0.5), while females needed 1.2 mm (SD = 0.5). In Class II, males required 1.1 mm (SD = 0.3), and females needed 1.5 mm (SD = 1.1). In Class III, females had a mean of 2.8 mm (SD = 1.6). For age groups, individuals under 30 needed an average of 1.2

mm (SD = 0.5) for Class I, while those aged 30 or older required 2.1 mm (SD = 0.8). Treatment duration showed that those treated for less than six months required an average of 1.1 mm (SD = 0.5) for Class I, while those treated for six months or more needed 1.4 mm (SD = 0.8). Regarding arch types, upper arches required an average of 1.4 mm (SD = 0.7) for Class I, whereas lower arches needed 1.5 mm (SD = 0.8). Finally, in terms of case severity, mild cases in Class I required 1.0 mm (SD = 0.1), moderate cases needed 1.4 mm (SD = 0.7), and severe cases averaged 2.3 mm (SD = 0.5).

DISCUSSIONS

This study aims to assess the performance of clear aligners in treating different Angle's classifications of malocclusions when combined with various degrees of severity cases. This study evaluated the predicted treatment in comparison with the achieved treatment results.

67.8% of cases from different malocclusion were treated without needing refinement. This finding agrees with various previous studies. Haouili et al. found clear aligner accuracy is around 50% (10). Another study revealed the accuracy of resolving crowding is 65% (19).

Furthermore, in our study, the percentage of accurate treatment outcomes differs with different malocclusions; in Class I, the predictability is 72%, and 56% and 70% in Class II and III, respectively. Our study revealed that Class II is 2.3 times more likely to need refinement than Class I and cases with Class III are 1.3 times more likely to need refinement than Class I. This indicates cases with Class I malocclusion would have a higher predictability rate when treated with clear aligners. Brian et al. studied the

treatment outcome of 80 patients treated with clear aligners. They divided the patients into equal groups: Class I and Class II. They compared the treatment outcomes in both groups using the American Board of Orthodontics Model Grading System. They found no improvements in the anterior-posterior correction in the Class II group. Both groups have significant improvement in alignment and proximal contacts scores. In addition, refinement was necessary to correct the posterior open bite at the end of the treatment (20).

The severity of the case plays a role in determining the refinement needs. Our findings showed mild cases of Class I, II, and III malocclusions have better accuracy than moderate and severe cases. Other studies confirmed clear aligners performed better with mild cases (12,21). This indicates careful treatment planning and the need to include different auxiliaries, such as elastics and mini-implants with clear aligners in treating complex cases.

It is essential to acknowledge some of the limitations of the study. The primary research limitation is that patient compliance is crucial to the effectiveness of clear aligner therapy. This emphasizes how vital patient compliance is to the success of their treatment. The findings' generalizability and statistical power could have been affected by various circumstances. Firstly, there were only a few participants in the study. Moreover, the bulk of participants (N=100) were female.

Also, the sample was selected using convenience sampling. Furthermore, not every malocclusion has the same number of cases. Lastly, each patient was recruited from a single center. As a result, the data should be interpreted carefully.

The study suggests that clear aligners might be more effective for patients with Class I malocclusion compared to those with Class II and III, highlighting the need for tailored orthodontic strategies based on malocclusion classification. Future research

might need to expand the sample size, exploring the long-term outcomes of clear aligner treatment, and investigating the underlying factors contributing to the higher refinement rates observed in moderate and severe cases.

CONCLUSIONS

This study showed that clear aligners are more effective for treating Class I malocclusion, with higher refinement needs observed in Class II and III cases. Further research is essential to explore long-term effects and optimize treatment strategies for varying malocclusion classifications.

DISCLOSURE

The author reports no conflicts of interest in this work.

Variable	Angle's classifications				P-value*
		Class I	Class II	Class III	
Total	115	66 (57.4%)	32 (27.8%)	17 (14.8%)	
Gender					
Male	15 (13.0%)	7 (46.7%)	4 (26.7%)	4 (26.7%)	0.367
Female	100 (87.0%)	59 (59.0%)	28 (28.0%)	13 (13.0%)	
Age (years)					
< 30	62 (53.9%)	38 (61.3%)	10 (16.1%)	14 (22.6%)	0.002
≥ 30	53 (46.1%)	28 (52.8%)	22 (41.5%)	3 (5.7%)	
Treatment length					
< 6 months	52 (45.2%)	30 (57.7%)	13 (25.0%)	9 (17.3%)	0.711
≥ 6 months	63 (54.8%)	36 (57.1%)	19 (30.2%)	8 (12.7%)	
Arch					
upper	54 (47.0%)	32 (59.3%)	14 (25.9%)	8 (14.8%)	0.908
Lower	61 (53.0%)	34 (55.7%)	18 (29.5%)	9 (14.8%)	
Type of the cases					
Spacing	60 (52.2%)	42 (70.0%)	12 (20.0%)	6 (10.0%)	0.017
Crowding	55 (47.8%)	24 (43.6%)	20 (36.4%)	11 (20.0%)	
Severity of the case					
Mild	63 (54.8%)	37 (58.7%)	15 (23.8%)	11 (17.5%)	0.070
Moderate	36 (31.3%)	22 (61.1%)	13 (36.1%)	1 (2.8%)	
Severe	16 (13.9%)	7 (43.8%)	4 (25.0%)	5 (31.3%)	
Need of refinement					
No	78 (67.8%)	48 (61.5%)	18 (23.1%)	12 (15.4%)	0.253
Yes	37 (32.2%)	18 (48.7%)	14 (37.8%)	5 (13.5%)	

Table 1 Demographic and Clinical Variables by Angle's Classifications

*Chi square test

Table 2. Linear regression analysis of the association between Angle's classifications and the mean millimetres of spacing or crowding at the end of the treatment

Variable	Reference group	Coefficient*	95% CI ^a	P-value
Angle's classifications				
Class II	Class I	-.06	(-0.33-0.22)	0.688
Class III	Class I	0.64	(0.29-0.99)	<0.01

*Adjusted for gender, age, the need of refinement, arch type and the type of the case (has crowding or spacing).

^a 95 % confidence interval.

Table 3. Logistic regression analysis of the association between Angle's classifications and the need for refinement at the end of the treatment

Variable	Reference group	Adjusted odds ratio*	95% CI ^a	P-value
Angle's classifications				
Class II	Class I	2.3	(0.9,6.0)	0.086
Class III	Class I	1.3	(0.4,4.5)	0.698

*Adjusted for gender, age, the need of refinement, and arch type.

^a 95 % confidence interval.

Table 4 Mean of millimetres needed refinement at the end of the treatment by the Angle's classifications.

Variable	Angle's classifications		
	Class I mm* (SD) ^a	Class II mm (SD)	Class III mm (SD)
Total			
Gender			
Male	2.5 (0.5)	1.1 (0.3)	0
Female	1.2 (0.5)	1.5 (1.1)	2.8 (1.6)
Age (years)			
< 30	1.2 (0.5)	1.5 (0.7)	2.5 (1.8)
≥ 30	2.1 (0.8)	1.4 (1.0)	3.3 (1.8)
Treatment length			
< 6 months	1.1 (0.5)	1.3 (.9)	0
≥ 6 months	1.4 (0.8)	1.5 (1.1)	2.8 (1.6)
Arch			
upper	1.4 (0.7)	1.4 (1.2)	2 (0.1)
Lower	1.5 (0.8)	1.5 (0.8)	3.37 (2.1)
Severity of the case			
Mild	1.0 (0.1)	0.7 (0.3)	1 (0.02)
Moderate	1.4 (0.7)	1.8 (1.1)	0
Severe	2.3 (0.5)	1.5 (0.5)	3.3 (1.5)

* Millimetres

^a Standard deviation

REFERENCES

1. Proffit W, Fields HW. Contemporary Orthodontics. 3rd ed. St Louis: Mosby; 2000, 9–13,141–142, 161–166, 248–252.
2. Angle EH. Treatment of malocclusion of the teeth and fractures of the maxillae. In: Angle's System. 6th ed. Philadelphia: SS White Dental Mfg Co; 1900.
3. Inchingolo A.D., Malcangi G., Semjonova A., Inchingolo A.M., Patano A., Coloccia G., Ceci S., Marinelli G., Di Pede C., Ciocia A.M., et al. Oralbiotica/Oralbiotics: The Impact of Oral Microbiota on Dental Health and Demineralization: A Systematic Review of the Literature. Children. 2022;9:1014. doi: 10.3390/children9071014.
4. Kravitz ND, Kusnoto B, BeGole E, Obrez A, Agran B. How well does Invisalign work A prospective clinical study evaluating the efficacy of tooth movement with Invisalign. Am J Orthod Dentofacial

Orthop.

5. Cardoso, P. C., et al. (2020). Pain level between clear aligners and fixed appliances: A systematic review. *Progress in Orthodontics*, 21(1), 3. <https://doi.org/10.1186/s40510-019-0303-z>
6. Aman, C., et al. (2018). Apical root resorption during orthodontic treatment with clear aligners: A retrospective study using cone-beam computed tomography. *American Journal of Orthodontics and Dentofacial Orthopedics*, 153(6), 842–851. <https://doi.org/10.1016/j.ajodo.2017.10.026>
7. Gandhi, V., et al. (2021). Comparison of external apical root resorption with clear aligners and pre-adjusted edgewise appliances in non-extraction cases: A systematic review and meta-analysis. *European Journal of Orthodontics*, 43(1), 15–24. <https://doi.org/10.1093/ejo/cjaa013>
8. Rossini, G. et al. Periodontal health during clear aligners treatment: A systematic review. *Eur. J. Orthod.* 37(5), 539–543. <https://doi.org/10.1093/ejo/cju083> (2015).
9. Baldwin, D. K. et al. Activation time and material stiffness of sequential removable orthodontic appliances. Part 3: Premolar extraction patients. *Am. J. Orthod. Dentofac. Orthop.*
10. Haouili, N. et al. Has Invisalign improved? A prospective follow-up study on the efficacy of tooth movement with Invisalign. *Am. J. Orthod. Dentofac. Orthop.* 158(3), 420–425. <https://doi.org/10.1016/j.ajodo.2019.12.015> (2020).
11. Kravitz, N. D. et al. How well does Invisalign work? A prospective clinical study evaluating the efficacy of tooth movement with Invisalign. *Am. J. Orthod. Dentofac. Orthop.* 135(1), 27–35. <https://doi.org/10.1016/j.ajodo.2007.05.018>
12. Barashi MA, Habis RM, Alhazmi HA. Predictability of Orthodontic Space Closure Using Invisalign Clear Aligners: A Retrospective Study. *Cureus*. 2024 Mar 22;16(3):e56706. doi: 10.7759/cureus.56706. PMID: 38646261; PMCID: PMC11032648.
13. Kravitz, N. D. et al. Influence of attachments and interproximal reduction on the accuracy of canine rotation with Invisalign. A prospective clinical study. *Angle Orthod.* 78(4), 682–687. [https://doi.org/10.2319/0003-3219\(2008\)078\[0682:Joaaair\]2.0.Co;2](https://doi.org/10.2319/0003-3219(2008)078[0682:Joaaair]2.0.Co;2) (2008).
14. Simon, M. et al. Treatment outcome and efficacy of an aligner technique—regarding incisor torque, premolar derotation and molar distalization. *BMC Oral Health* 14, 68. <https://doi.org/10.1186/1472-6831-14-68> (2014).
15. Dianiskova S., Rongo R., Buono R., Franchi L., Michelotti A., D’Antò V. Treatment of mild Class II malocclusion in growing patients with clear aligners versus fixed multibracket therapy: A retrospective study. *Orthod. Craniofac. Res.* 2022;25:96–102. doi: 10.1111/ocr.12500.
16. Staderini E., Patini R., Meuli S., Camodeca A., Guglielmi F., Gallenzi P. Indication of clear aligners in the early treatment of anterior crossbite: A case series. *Dental Press J. Orthod.* 2020;25:33–43. doi: 10.1590/2177-6709.25.4.033-043.oar.
17. D’Antò V., Bucci R., De Simone V., Huanca Ghislanzoni L., Michelotti A., Rongo R. Evaluation of Tooth Movement Accuracy with Aligners: A Prospective Study. *Materials*. 2022;15:2646. doi: 10.3390/ma15072646.
18. Martina S., Martini M., Bordegoni M., Razionale A.V. Predictability of Root Movements Using Virtual Root Setup in a Patient With Periodontal Disease Treated With Clear Aligners. *Open Dent. J.* 2021;15:605–611. doi: 10.2174/1874210602115010605. [DOI] [Google Scholar]
19. THE RELIABILITY OF CLEAR ALIGNERS IN RESOLVING CROWDING DOI : 10.62610/RJOR.2024.4.16.25
20. Class II malocclusion correction with Invisalign: Is it possible? Patterson, Brian D. et al. *American Journal of Orthodontics and Dentofacial Orthopedics*, Volume 159, Issue 1, e41 - e48
21. Ke Y., Zhu Y., Zhu M. A Comparison of Treatment Effectiveness between Clear Aligner and Fixed Appliance Therapies. *BMC Oral Health*. 2019;19:24. doi: 10.1186/s12903-018-0695-z.