

Manuscript title: Orthodontic treatment with clear aligners for a patient with chronic periodontitis

Jiehua Zhang<sup>a</sup>; Jun Li<sup>b</sup>; Youjian Peng<sup>c</sup>

<sup>a</sup> Attending doctor, Department of Stomatology, Renmin Hospital of Wuhan University, Wuhan, Hubei, 4300060, China

<sup>b</sup> Associate Professor, Department of Stomatology, Renmin Hospital of Wuhan University, Wuhan, Hubei, China

<sup>c</sup> Professor and Department Chair, Department of Stomatology, Renmin Hospital of Wuhan University, Wuhan, Hubei, China

Corresponding author: Youjian Peng, Professor and Department Chair, Department of Stomatology, Renmin Hospital of Wuhan University, No. 99 Zhang Zhidong Road, Wuhan, Hubei, 430060 China

Work Telephone Numbers: (+86)027-88041911-85537

E-mail: 2528261347@qq.com

## ABSTRACT

This case report describes the treatment of an adult female patient with previous periodontal disease, Angle Class I malocclusion with extrusion, dental spaces, and pathologic tooth migration. The patient was treated with clear aligners, which provided effective control of the strength and direction of orthodontic forces after three months of systematic periodontal treatment. The Peer Assessment Rating (PAR) index was calculated from study models before and after treatment. The pretreatment PAR score was 24, and the posttreatment PAR score was 4. The PAR score for this patient changed by 83%. Satisfactory appearance and good function were achieved for this patient.

Keywords: Adult treatment, Periodontitis, Aligners, Malocclusion

## INTRODUCTION

Periodontal disease is highly prevalent in both developed and developing countries. Smoking, poor oral hygiene, diabetes mellitus, and genetics, among others, are risk factors associated with the development and/or progression of periodontitis.<sup>1</sup> Meanwhile, tooth misalignment increases plaque accumulation, predisposing people to the development of periodontal disease. Trauma from occlusion due to tooth position irregularity has also been found to have adverse effects on periodontal tissues. As the number of adults opting for orthodontic treatment continues to grow, orthodontists are more likely to manage patients with chronic periodontitis.<sup>2</sup> There is no consensus on the positive effects of orthodontic treatment on periodontal health. Nevertheless, current research suggests that orthodontic treatment has no significant negative impact on periodontal tissues when periodontal infection is under proper control.<sup>3,4</sup> Combined orthodontic-periodontal treatment is an effective approach for achieving pleasant function and esthetic results in patients with good periodontal health.<sup>5-8</sup> Maria et al. claimed that orthodontic movement could increase the amount of periodontal soft tissue and alveolar bone.<sup>9</sup> However, treating adult patients with chronic periodontal disease using fixed appliance therapy is a considerable challenge to orthodontists. Successful treatment of patients with periodontal disease requires specific mechanical and biomechanical considerations, regardless of whether either

labial or lingual fixed appliances are used.<sup>10,11</sup> Compared with conventional fixed appliances, clear aligners are a better choice for patients with periodontal disease because of their ease of oral hygiene maintenance, precise control of force, and mandibular incidence of root resorption.<sup>12-14</sup> This case report demonstrates the successful orthodontic treatment of a 24-year-old girl with inactive periodontitis with clear aligners.

#### DIAGNOSIS AND ETIOLOGY

A 24-year-old girl with severe periodontitis and pathologic tooth migration was referred to our orthodontic department. Her chief complaints were malposed maxillary and mandibular anterior teeth. She had no history of systemic disease. However, her mother suffered from misaligned teeth and periodontitis. Of note, poor oral hygiene and traumatic occlusal forces resulting from crooked teeth accelerate the progression of the disease, which in turn increases incisor irregularity. The patient had an almost symmetrical face and a straight facial profile. An Angle Class I canine relationship on the right side and a Class I molar relationship on both sides were observed, with a scissor bite of the maxillary left second premolar and a missing maxillary left canine. The main problem was located in the anterior region. Her mandibular incisors impinged on the lingual gingiva of the maxillary incisors. The maxillary central incisors and mandibular incisors were extruded with a severe lingual inclination and 8 mm overbite, whereas the maxillary lateral incisors were inclined labially (Figure 1). There was 4.0 mm of space (the space of the missing tooth was not included) within the maxillary arch and 1.0 mm in the mandibular arch. The anterior Bolton index was 78.6%, and the overall Bolton index was 93.5% (we measured the Bolton indexes with the hypothesis that the width of the left maxillary canine was equal to that of the right one). The curve of Spee was approximately 4.5 mm. The patient presented with generalized gingival recession, which was notably severe on the maxillary and lower anterior teeth and in the mandibular premolar region. The recession resulted in sensitivity to hot and cold temperatures, tooth mobility, and esthetic complaints. The initial periodontal conditions were measured using probing depth, plaque, bleeding on probing and tooth mobility. The patient's periodontal

disease was adequately controlled.<sup>15</sup> No tooth had a probing depth (PD) > 4 mm, the full-mouth plaque index was 18%, and the full-mouth percentage of positive bleeding on probing sites was 15% (Table 1). There was grade I mobility of the maxillary lateral incisors and grade II furcation of the mandibular right first molar.

The pretreatment lateral cephalogram is shown in Figure 2A. Pathological migration of the maxillary left lateral incisor was also observed on the panoramic radiograph (Figure 2B). Multiple sites of alveolar bone resorption could be discerned, especially in the anterior and premolar areas (Figure 3). Alveolar bone resorption in the mesial and distal regions of the maxillary left lateral incisor was extensive, involving half to two-thirds of the root. An infracrestal pocket was visible in the distal aspect of the mandibular left first premolar. Additionally, the maxillary central incisors and mandibular incisors showed severe lingual inclination (U1/SN 81.7°; IMPA 75.9°, Table 2). Cephalometric analysis showed a Class I skeletal pattern (ANB angle of 5.4°, Table 2) with a slightly high mandibular plane angle (MP-SN 39.2°, Table 2). Based on these findings, this adult patient was diagnosed with an Angle Class I malocclusion with a Class I skeletal pattern and severe periodontal disease.

#### TREATMENT OBJECTIVES

The primary goals of treatment for this patient with inactive periodontal disease were to

- Move teeth into proper alignment,
- Obtain normal overjet and overbite,
- Level the curve of Spee,
- Maintain the space (7.5 mm) between the maxillary left lateral incisor and maxillary left first premolar for an implant-supported prosthesis, upright the maxillary left lateral incisor, and close residual spaces,
- Correct the posterior scissor bite,
- Maintain the patient's facial profile, and
- Establish an esthetic smile by improving the smile arc, leveling the gingival height, and eliminating the lip trap at the maxillary lateral incisors.

## TREATMENT ALTERNATIVES

Alternative treatment strategies for this patient were restorative or prosthodontic treatment, conventional fixed orthodontic treatment, and orthodontic treatment with clear aligners. The patient was willing to establish appropriate alignment and occlusion of her anterior teeth, which meant that prosthodontic treatment was deemed inappropriate. Excessive tooth removal would be necessary to correct the facially inclined maxillary incisors. Preparing the incisors sufficiently for alignment would not only devitalize the teeth but also leave minimal natural tooth structure to retain the restoration. Orthodontics is typically a better option for the correction of apically positioned papillae of anterior teeth due to tooth alignment and interproximal bone loss. Orthodontics before restorative dentistry was recommended to the patient since her misaligned teeth could not be treated with restorative dentistry alone, and this approach could provide an excellent result.

In addition to restorative and prosthodontic options, orthodontic treatment by conventional fixed appliances and clear aligners could be used. Compared with conventional fixed braces, clear aligners are removable and allow patients to practice oral hygiene, which was crucial for this patient, who had periodontal disease. Clear aligners also have an advantage in the segmented movement of teeth to maintain a Class I molar relationship and are effective in controlling anterior intrusion. The displacement-driven system moved the teeth until they lined up with the following staged location of the clear aligners. Such gradual, segmented movement might minimize the excessive proclination of teeth and elicit predictable tooth movement. Clear aligners that required fewer appointments were more suitable for this patient since she lived far away from our office.

Finally, an interdisciplinary treatment plan, including orthodontic treatment with clear aligners and prosthodontic restoration, as well as a strictly supervised oral hygiene program, was adopted. The periodontal pocket depth and bleeding on probing for periodontal disease were monitored by periodontists throughout the orthodontic treatment period.

## TREATMENT PROGRESS

Before orthodontic treatment, systemic periodontal therapy was performed, including scaling, root planing, periodontal flap surgery and oral hygiene instruction. After six months of periodontal treatment, the patient was referred to our orthodontic office. Periodontal maintenance was arranged every three months during orthodontic treatment.

Clear aligners (Angelalign, China) were used to correct the overerupted and inclined teeth and close the spaces in the maxillary and mandibular arch. The patient was instructed to wear each aligner for approximately 22 hours every day and move on to the next aligner in the series after 14 days. The treatment progress was divided into two phases: the initial stage (maxillary: 28; mandibular: 28) and refinement stage (maxillary: 16; mandibular: 11).

A total of 1.9-2.4 mm of anterior incisor intrusion, no extrusion of the posterior teeth, and 14-15 degrees of labial crown movement of lingually inclined incisors were designed in the initial stage of treatment. Optimized attachments and one conventional transverse rectangular attachment were placed on the premolars and the right maxillary canine, providing anchors for the anterior intrusion. Bite ramps built into the lingual surface of the maxillary aligners and elastic deformation of the aligner material generated the force for the intrusion during the first stage (Figure 4A). Interproximal reduction (IPR) was employed to reduce the black triangle in the mandibular anterior teeth and provide space for mandibular incisor intrusion. To perform this procedure, fine diamond strips were utilized until the tooth contacts were broken. Then, high-speed burs were used to create 0.5 mm of space in each interproximal contact from the mesial mandibular left second premolar to mesial mandibular right canine (Figure 4B). Intrusion and lingual or labial movement of the anterior incisors were achieved in 28 steps. The amount of movement was 0.1 mm and less than 1° in one of three dimensions at each step. Maxillary lateral incisors were intruded and moved lingually. Maxillary central incisors and mandibular incisors were intruded and moved labially. The amount of labial movement of the mandibular incisors was no more than that of the maxillary incisors to prevent traumatic occlusion. The left posterior scissor bite was improved by intrusion and lingual inclination of the

maxillary second premolar and buccal inclination of the mandibular second premolar with a small amount of intrusion.

At the end of the initial stage of treatment with aligners 28, we compared the final tooth position with the planned tooth movement (Figure 5). The results showed that leveling of the bimaxillary arch had almost been completed, the space had been closed, and the deep bite had been corrected. However, the left maxillary lateral incisor was still tilted mesially, and the posterior teeth were not in sound occlusion. Refinement with an additional 16 maxillary aligners and 11 mandibular aligners was performed. An additional 22 degrees of mesial root movement of the left maxillary lateral incisor was designed. Rectangular attachments and optimized attachments were bonded to all the premolars and first molars for posterior occlusal settling. Precision cut-outs where buttons were placed were designed for cross elastics. Cross elastics from buttons placed on the lingual side of the second mandibular premolar and buccal side of the second maxillary premolar on the left side and anterior bite ramps were used to eliminate the posterior scissor bite with a bite depth greater than 30%.<sup>16</sup> Intermaxillary cross elastics (size 3/16 medium, 3.5 oz) were used for four weeks.

After 22 months of orthodontic treatment, the mesial inclination of the maxillary left lateral incisor was improved but not corrected. We made additional adjustments for the patient, but she was very pleased with the treatment outcome and refused to continue wearing the adjustment appliances (which is why attachments can be seen in the posttreatment intraoral photographs) (Figure 6). The active treatment lasted 22 months, with 44 maxillary and 39 mandibular aligners. After inactive therapy for 7 months, the patient was then referred for prosthodontic treatment. A Maryland bridge rather than an implant-supported prosthesis was used for the patient due to the angulation of the maxillary left lateral incisor. The patient was instructed to wear vacuum-formed retainers full-time. Periodontal maintenance appointments were recommended to be arranged every four months.

## TREATMENT RESULTS

Functional and esthetic outcomes were achieved after orthodontic treatment. The harmony between the arc of curvature of the edges of the maxillary incisors and the

maxillary border of the mandibular lip resulted in a perfect smile. Normal overjet and overbite were established with better torque and occlusion in the anterior region. The Class I canine and molar relationship was maintained, with a slight midline deviation between the maxillary and mandibular midlines (Figure 6). The pretreatment Peer Assessment Rating (PAR) score in this case was 24, and the posttreatment PAR score was 4. The reduction (percentage) in the PAR score was 83%, indicating improvement.

No significant difference in sagittal skeletal outcomes was observed, as shown in Figure 7A. The posttreatment cone-beam computed tomography (CBCT) image showed proper space closure and parallel roots, except for the maxillary left lateral incisor (Figure 7B). Sound periodontal support in the mandibular left first and second premolars was maintained and even improved after orthodontic treatment (Figure 8, Table 3). The most notable cephalometric changes were the labial tipping and intrusion of the maxillary central incisors and mandibular incisors. The position of the anterior incisors in the basal bone was improved (U1/SN 93.5°; IMPA 87.9°, Table 2). Moreover, the buccal bone thickness of the maxillary incisors increased. The posttreatment lateral cephalometric analysis and superimposition displayed no significant skeletal changes (ANB, 5.4°, Table 2, Figure 9) and revealed a slight change in the mandibular plane angle (MP-SN, 40.3°, Table 2, Figure 9). Mandibular movements were regular, without signs or symptoms of temporomandibular disorders. The active treatment duration was 22 months. The seven months of posttreatment records showed that the results remained stable, and an adhesive fixed partial denture was placed in the maxillary arch (Figure 10).

## DISCUSSION

Orthodontic treatment using clear aligners assisted by periodontal treatment achieved an excellent final result in a conscientious and precise manner, with the preferable occlusal force through the teeth, thus preventing traumatic occlusion and periodontitis.<sup>17</sup> The proclination of the maxillary left lateral incisor and extrusion of both maxillary and mandibular incisors in this patient due to her periodontal disease were challenges for the prosthodontists. Importantly, prosthodontic treatments,

including removable partial dentures, fixed bridges, and dental implants, cannot resolve a deep overbite and esthetic problems in the anterior region. The orthodontic treatment of adult patients with periodontitis could achieve a more stable, functional occlusal relationship, as other studies have suggested.<sup>18,19</sup> Before orthodontic treatment, periodontal therapy was performed until the periodontal condition was stable. Moreover, the patient's periodontal status was strictly monitored before, during, and after active orthodontic therapy.

Some researchers have reported no significant differences in plaque or gingival indexes between treatment with fixed appliances and clear aligners in periodontitis patients.<sup>17</sup> In general, fixed orthodontic appliances can increase plaque accumulation and bacterial colonization, reducing the efficacy of oral hygiene.<sup>20</sup> Clear aligners have increased advantages over regular fixed orthodontic appliances.<sup>21,22</sup> Jiang et al. also indicated in their systematic review that clear aligners, as a type of removable appliance, were more conducive to oral hygiene and periodontal health than fixed appliances.<sup>14</sup> Better periodontal maintenance was one of the reasons for treatment with clear aligners in this case.

Carefully created designs contributed to the patient's good occlusion and periodontal health. A 0.75-mm-thick appliance was applied to achieve smaller tooth movements of 0.10 mm and 1 degree per step, compared with 0.25 mm and 2 degrees per step in healthy patients without periodontitis. The precise design of the amount of movement induced by clear aligners can more accurately control the size of the applied force. The instantaneous pressure applied when the aligners were inserted and removed was improved by blocking out the undercuts and trimming the edge of the aligners 1-3 mm shorter than those used in healthy patients according to the periodontal status (Figure 11). These design features also made the aligners easy to wear considering the diverse angles between the left central and lateral incisors. All the above modifications were used to achieve the light orthodontic forces suggested in adults with a history of periodontal disease.

Planning the design of clear aligners for patients with a deep overbite is still a major challenge for orthodontists. Deep overbites are generally corrected by posterior

extrusion and/or anterior intrusion. Due to the profile and lip position in this case, this patient was better suited to being treated by anterior intrusion, which included relative intrusion and some actual intrusion (Figure 9). The relative intrusion of anterior teeth was gained through the labial inclination of the maxillary central incisors and mandibular incisors. Actual intrusion was not pursued until the anterior incisors were appropriately positioned within the alveolar bone. Incisal flaring is often observed as a side effect when intruding teeth by using fixed appliances. It is also troublesome to control the extent of labial movement of the maxillary central incisors using a fixed orthodontic appliance, preventing the proclination of the incisors. For this patient, the excessive labial inclination of the maxillary incisors was harmful to the profile. However, we improved the torque of the maxillary central incisors step by step and evaluated the relationship between the axial inclination of the maxillary incisors and the lip position in a timely manner by using clear aligners.

The attachment design also took periodontal health into consideration. A small amount of tooth movement in the posterior segments was allowed because posterior teeth were used as anchors for correction of the severe deep bite during the first treatment phase. Since the larger teeth of periodontal patients allow aligners to fit firmly, only three beveled horizontal rectangular attachments and a rectangular attachment were placed on the premolars and the right maxillary canine. This design also made it easier to insert and remove the aligners, thus further reducing the forces experienced by the patient when inserting and removing the aligners. After the anterior teeth were correctly oriented, attachments for rotation correction and root uprighting were set on the posterior teeth for occlusal adjustment during the refinement process.

Ultimately, excellent control on torque of incisors facilitates the stabilization of anterior tooth roots in the central region of the alveolar bone, eliminating the abnormal direction of the bite force and helping to maintain good periodontal status. The results demonstrated that the orthodontic therapy did not result in any irreversible periodontal destruction. This interdisciplinary approach led to good functional and esthetic outcomes, providing the optimal treatment plan in a complex clinical case.

These results are in agreement with those of a study by Lee.<sup>23</sup> Follow-up at seven months posttreatment confirmed the excellent choice of treatment design and the stability of the occlusion.

However, there are still some deficiencies in this case. A slight deviation of the mandibular midline remained. The results might have been better if the patient had finished the modification phase. Additionally, the maxillary lateral incisor showed slight mesial inclination. We speculated that the angulation was not corrected due to the attachment design. During the initial stage of treatment, no attachments were added to the maxillary left lateral incisor to avoid applying too much force to the teeth while inserting and removing the aligners. During treatment refinement, an optimized attachment was used. However, for teeth that need excellent control of root angulation, the optimized attachments are not as effective as root control attachments. Root control attachments include a gingival attachment to allow the aligner to produce a force in the direction of root movement, and the second attachment can be placed occlusally, providing a second-order moment. Therefore, root control attachments are recommended to achieve good root angulation.

## Conclusions

The mechanism responsible for overbite opening in this patient was primary proclination of the inclined incisors and intrusion of anterior incisors. Continuous and repeated professional periodontal maintenance, good oral hygiene, and motivation are also vital elements for the successful orthodontic management of periodontal patients. Orthodontic treatment with clear aligners for periodontal patients may provide a substantial mutual benefit in periodontal therapy and prosthodontic treatment. Clear aligners might be better recommended for patients with adequately controlled chronic periodontitis.

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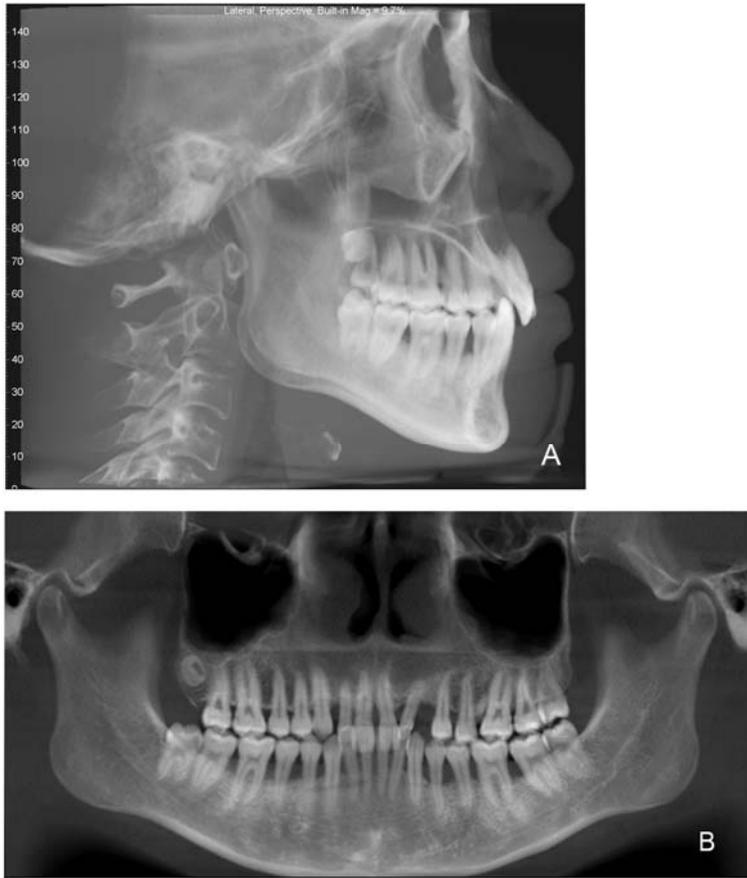
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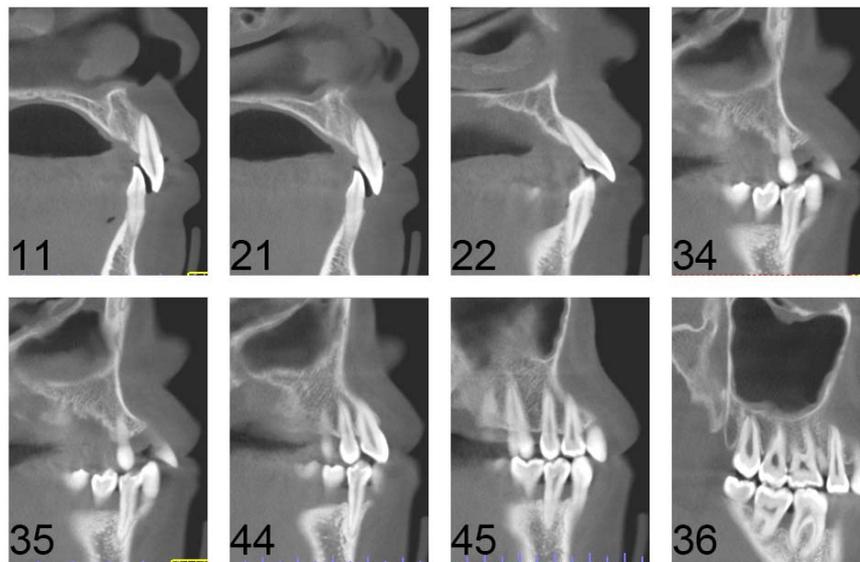
## Figures



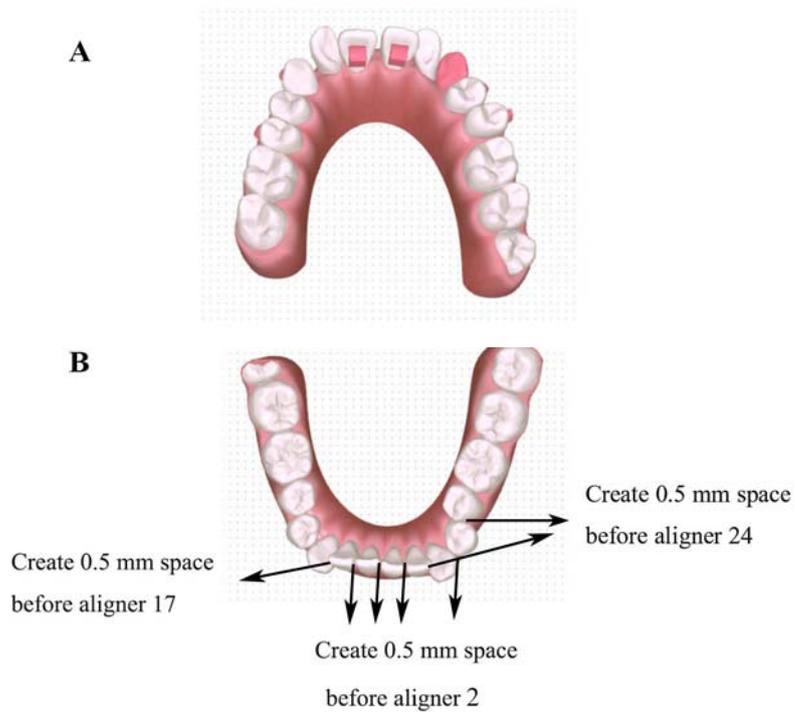
**Figure 1.** Pretreatment facial and intraoral photographs of an adult with inactive periodontal disease.



**Figure 2.** Initial CBCT scan showing cephalometric (A) and panoramic radiographs (B) of an adult with inactive periodontal disease.



**Figure 3.** Initial CBCT scan showing dental radiographs of an adult with inactive periodontal disease.



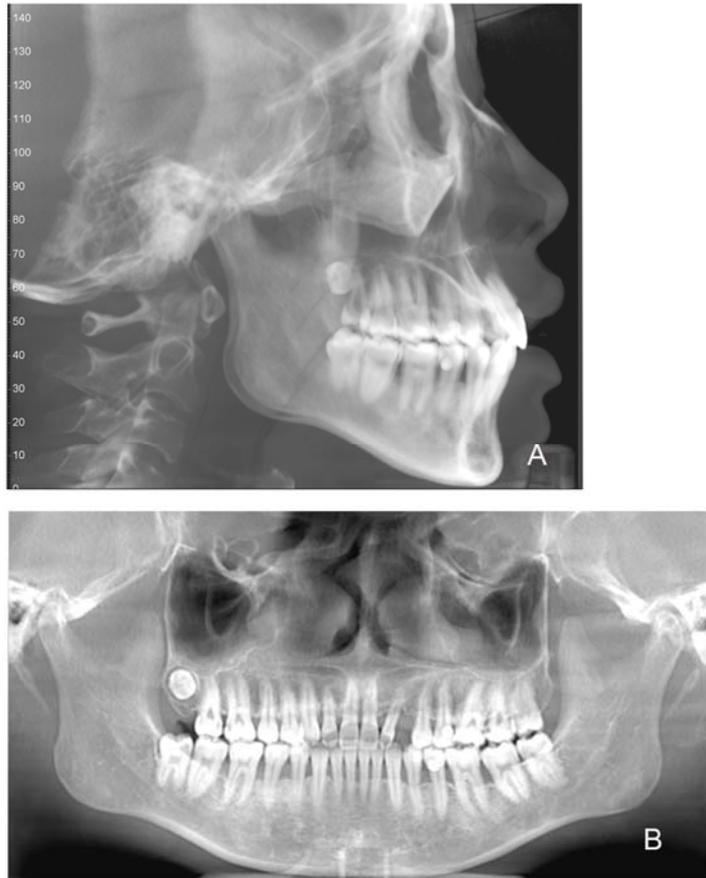
**Figure 4.** A, Bite ramps on the lingual surface of the maxillary aligners. B, Interproximal reduction (IPR) chart.



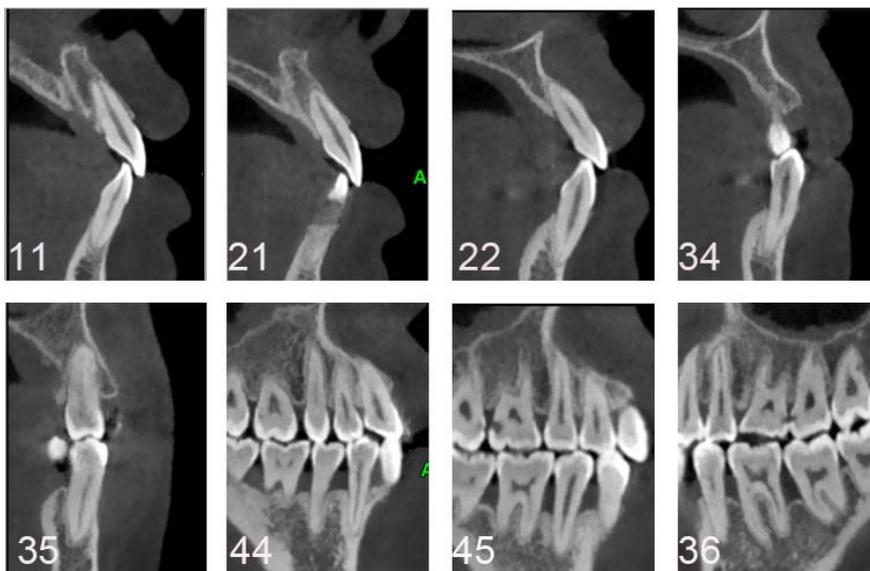
**Figure 5.** Treatment progress: intraoral photographs 14 months after the start of orthodontic treatment as compared to her planned tooth positions. The deep bite was corrected, and the spaces between teeth were closed.



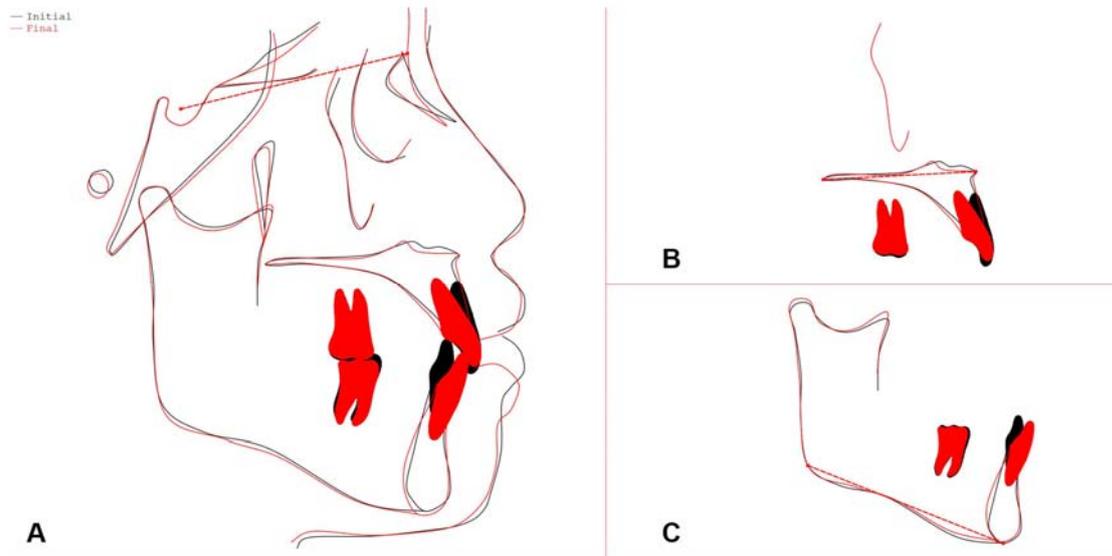
**Figure 6.** Posttreatment facial and intraoral photographs of an adult with inactive periodontal disease treated with clear aligners. Proper overjet and overbite were achieved, and the lateral profile was maintained.



**Figure 7.** Posttreatment CBCT scan showing cephalometric and panoramic radiographs of an adult with inactive periodontal disease treated with clear aligners.



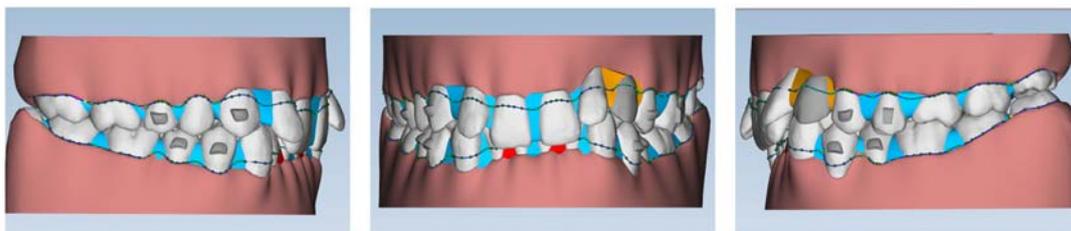
**Figure 8.** Posttreatment CBCT scan showing dental radiographs of an adult with inactive periodontal disease treated with clear aligners.



**Figure 9.** Superimposed cephalometric tracings showing the changes from pretreatment (black) to posttreatment (red) in an adult with inactive periodontal disease treated with clear aligners: A, Superimposed on the sella-nasion plane at sella; B, Superimposed on the palatal plane at ANS; C, Superimposed on the mandibular plane at the menton. The intrusion of the incisors was achieved and inclination of the anterior teeth were improved.



**Figure 10.** Facial and intraoral photographs at seven months after treatment. Prosthodontic rehabilitation of the maxillary left canine yielded optimal esthetic results.



**Figure 11.** Blocking out of the undercuts and trimming the line of the aligners. These designs applied gentle instantaneous force when inserting and removing the aligners to protect the periodontal tissues.

**Table 1.** Results of pretreatment periodontal examination.

Table 1. Results of pretreatment periodontal examination														
Maxillary teeth	17	16	15	14	13	12	11	21	22	23	24	25	26	27
Pocket depth(labial)(mm)	111	111	111	111	112	212	212	212	234		222	323	422	222
Bleeding on probing					*		*		***					
Pocket depth(lingual)(mm)	111	111	111	111	111	212	323	333	223		222	212	322	222
Bleeding on probing													*	
Mandibular teeth	47	46	45	44	43	42	41	31	32	33	34	35	36	37
Pocket depth(labial)(mm)	113	343	323	323	323	122	212	222	222	222	244	433	324	322
Bleeding on probing		*	***	***	*					*	***	*		
Pocket depth(lingual)(mm)	122	333	333	323	322	322	222	222	222	323	323	223	234	222
Bleeding on probing		***	*	**	*					*	**			

\* The asterisks indicate bleeding on probing

**Table 2.** Cephalometric measurements.

Table 2. Cephalometric measurements			
Measurements	Mean ± SD	Pretreatment	Posttreatment
SNA, °	82.0 ± 3.5	83.4	83.1
SNB, °	80.0 ± 3.0	78.0	77.7
ANB, °	3.0 ± 2.5	5.4	5.4
MP-SN, °	33.0 ± 6.0	39.2	40.3
IMPA, °	95.0 ± 7.0	75.9	87.9
FMA, °	26.0 ± 4.5	29.7	30.7
U1-SN, °	102.1 ± 5.5	81.7	93.5
U1-NA, mm	4.3 ± 2.7	-0.8	1.9
L1-NB, mm	4.0 ± 1.8	4	7.6
U1/L1, °	130.0 ± 6.0	163.2	138.3
UL-EP, mm	-1.5 ± 2.0	0.0	1.0
LL-EP, mm	-2.0 ± 2.0	1.0	2.0
Overjet, mm	2.5 ± 2.5	5.6	3.2
Overbite, mm	2.5 ± 2.0	8.6	2.4

**Table 3.** Results of posttreatment periodontal examination.

Table 3. Results of posttreatment periodontal examination														
Maxillary teeth	17	16	15	14	13	12	11	21	22	23	24	25	26	27
Pocket depth(labial)(mm)	111	111	111	111	111	212	211	112	212		212	212	222	222
Bleeding on probing														
Pocket depth(lingual)(mm)	111	111	111	111	111	112	211	112	222		222	212	222	222
Bleeding on probing														
Mandibular teeth	47	46	45	44	43	42	41	31	32	33	34	35	36	37
Pocket depth(labial)(mm)	113	212	222	111	222	222	212	222	222	212	233	322	323	322
Bleeding on probing											***	*		
Pocket depth(lingual)(mm)	122	333	333	323	322	322	222	222	222	323	323	223	234	222
Bleeding on probing											***	**	**	*

\* The asterisks indicate bleeding on probing