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*Original Article*

# The effects of traditional fixed orthodontic treatment and bracket-free orthodontic treatment on children with malocclusion

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**Abstract:** Objective: This study was designed to compare the application effects of traditional fixed orthodontic treatment and bracket-free orthodontic treatment in the orthodontics of children with malocclusion. Methods: 103 children with malocclusion were retrospectively analyzed for their clinical data and divided into two groups based on the treatment method each received, including a control group (CG) for the traditional fixed orthodontic treatment, and an observation group (OG) for the bracket-free orthodontic treatment. The two groups were compared in their clinical effects, plaque index (PLI), SUICUS bleeding index (SBI), SUICUS probing depth (SPD), and gingival index (GI) before and after the treatment, their satisfaction after the malocclusion orthodontics and the incidences of adverse reactions during the treatment. Results: While no significant differences were found between the two groups in terms of their GI and SPD after the treatment, the OG reported lower SBI and PLI and higher language function, convenience, chewing function, fixation function, aesthetics, and comfort after treatment scores ($P$<0.05). The orthodontic times of tilted teeth and transpositioned teeth in the observation group was shorter than they were in the control group ($P$<0.05). Furthermore, the total effective rate was 96.15% in the OG, and 74.51% in the CG ($P$<0.05). For the incidences of endodontitis, caries, and oral mucosa injuries during the treatment, the reported data were 1.92%, 3.85% and 0.00% in the OG and 29.41%, 23.53% and 27.45% in the CG ($P$<0.05). Conclusion: Bracket-free orthodontic treatment yielded more favorable effects than traditional fixed orthodontic treatment in the orthodontics of children with malocclusions. It is advantageous to maintain periodontal health, improve the patients' satisfaction with orthodontics, and reduce the incidences of adverse reactions during treatment.

**Keywords:** Malocclusion, orthodontics, traditional fixed orthodontic treatment, bracket-free orthodontic treatment, periodontal index (PI)

## Introduction

As a clinically common dental disease, malocclusion develops in children due to congenital genetic factors, acquired environmental factors during their growth and development, such as obstacles during dental transition, harmful oral habits and diseases, or periodontosis or an injury after growth and development. It leads to facial deformity, an abnormal jaw size and position, an abnormal occlusal relationship between the upper and lower dental arches, and tooth malalignment [1, 2].

Generally speaking, there are many factors or mechanisms contributing to malocclusion independently or concurrently [3]. In addition to its obvious effects on craniofacial development, oral health and function, as well as appearance, the disease may also compromise the mental health of patients such that they may be self-abased. Therefore, the timely adoption of appropriate methods plays a key role [4, 5]. Previously, traditional fixed orthodontic treatment was often adopted for children with malocclusion, but the fixed appliance not only significantly affects their periodontal health - it also causes impediments to some health measures, such as tooth brushing to a certain degree, resulting in more severe inflammation of the gingival tissue [6]. Furthermore, clinical studies have also revealed that traditional fixed

appliances are also a cause of gingival hemorrhage and swelling. Henceforth, a more appropriate treatment for malocclusion would be deeply appreciated clinically [7]. In recent years, with the advancement in medical technology, Bracket-free orthodontic treatment has achieved extensive application in the clinic. It is computer-based to design and fabricate flexible fixed appliances which work on a small scale to continuously correct teeth and provides a references to doctors for the analysis of tooth movement [8].

Given the limitations of traditional fixed orthodontic treatment in children with malocclusion, this study examines a more innovative and feasible bracket-free orthodontic treatment for the same purpose.

## Materials and methods

### *Materials*

103 children with malocclusion in our hospital were included in the study, retrospectively analyzed for their clinical data, and divided into two group based on the treatment method. 51 patients, including 35 males and 16 females, were assigned to the CG for traditional fixed orthodontic treatment, while the remaining 52 children, consisting of 36 males and 16 females, were placed in the OG for bracket-free orthodontic treatment. (1) Inclusion criteria: patients ranging in age from 6 to 15 and patients diagnosed with Angle's class I or II malocclusion due to rotated or tilted premolar teeth or molars. They agreed to strictly abide by the doctor's advice during the treatment, guaranteed that they had no previous history of orthodontics, systematical diseases, or other major systematical diseases, and granted informed consent along with their parents to participate in the study, which was approved by the Ethics Committee of Fuyang District Chinese Medicine Hospital of Hangzhou. Exelcymosis was not adopted for orthodontics. (2) Exclusion criteria: some patients were excluded as they had a history of orthodontics, oral mucosa diseases, gingivitis, and periodontitis in the progressive stage, severe bony malocclusion and crowded misalignment, harmful oral health habits, or they required exelcymosis for orthodontics.

### *Methods*

The patients in the OG underwent bracket-free orthodontic treatment. The malformation type was determined based on the dento-maxillofacial photos and x-ray images, and an orthodontics plan was established. The orthodontics process was simulated three-dimensionally using OrthoDS in the form of animation, and bracket-freeing fixed appliances were fabricated with transparent polymers depending on the 3-D stereo technology with a computer. All the patients were required to wear the fixed appliance for at least 20 hours each day except for tooth brushing and eating; they were asked to return to the hospital once every 4 to 6 weeks for a careful check of their tooth movement, and some targeted treatments if necessary, including jaw adjustment, interproximal enamel reduction, and bonding accessories. The fixed appliance was replaced every 2 weeks, and the treatment lasted 6 months.

For the patients in the CG, traditional fixed orthodontic treatment was adopted, including an identification of the type of malformation and the modeling of a fixed appliance based on the dento-maxillofacial photos and x-ray images. Afterward, 3M arch-wire brackets were used for the fixation, during which, the procedures for the orthodontics with straight wires were strictly followed. The treatment lasted 6 months.

### *Observation indexes*

(1) Efficacy evaluation criteria: the treatment was determined to be ineffective if the malocclusion was not corrected, the teeth were not aligned, or the anterior teeth overdenture was not significantly improved, and effective if the malocclusion was corrected, the teeth were aligned, and the anterior teeth overdenture was significantly improved, or markedly effective if all the teeth were arranged neatly without any anterior teeth overdenture or malocclusion [9]. The total effective rate = effective rate + markedly effective rate.

(2) PI [10]: before and after the treatment, the PI was measured in both groups: ① GI: probing and visual examination were adopted to evaluate the conditions at the gingival margin of the PI teeth, disto- and mesio-labial papilla, as well as the middle antelabium. 3 points were

**Table 1.** Comparison of the general clinical data in the two groups [n (%)]/($\bar{x} \pm s$)

| Category | | OG (n=52) | CG (n=51) | $t/X^2$ | *P* |
|---|---|---|---|---|---|
| Gender (n) | Male | 36 (69.23) | 35 (68.63) | 0.004 | 0.947 |
| | Female | 16 (30.77) | 16 (31.37) | | |
| Age (y) | | 8.96±1.69 | 8.99±1.63 | 0.092 | 0.927 |
| Course of disease (y) | | 1.28±0.15 | 1.32±0.13 | 1.445 | 0.152 |
| Malformation type | | | | | |
| Angle's Class I malocclusion | | 42 (80.77) | 40 (78.43) | 0.087 | 0.768 |
| Angle's Class II malocclusion | | 10 (19.23) | 11 (21.67) | | |

**Table 2.** Comparison of the clinical efficacy in the two groups [n (%)]

| Group | n | Markedly Effective | Effective | Ineffective | Total Effective |
|---|---|---|---|---|---|
| CG | 51 | 21 (41.18) | 17 (33.33) | 13 (25.49) | 38 (74.51) |
| OG | 52 | 32 (61.54) | 18 (34.62) | 2 (3.85) | 50 (96.15)* |
| $X^2$ | | | | | 9.694 |
| *P* | | | | | 0.002 |

Not: *indicates P<0.05 as compared with the CG.

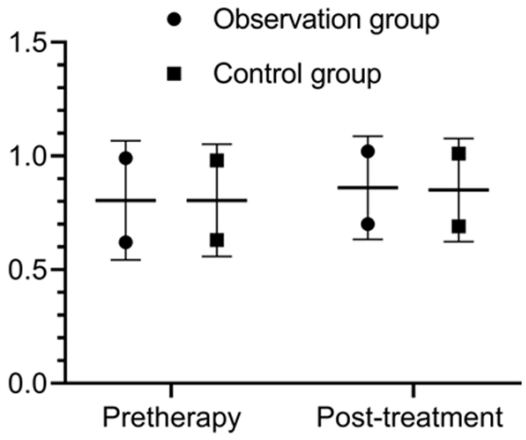


**Figure 1.** Comparison of the GI in the two groups before and after the treatment. No statistical difference was found between the OG and the CG in the GI before or after the treatment (P>0.05).

assigned to the results in the case of gingival ulcers or erosion or a tendency to bleed, 1 point in the case of slight gingival swelling with no blood when probed, 2 points in the case of obvious gingival swelling, or 0 points in the case of no gingival swelling and bleeding when probed. ② SPD: the 4 incisor teeth at the lower jaw were selected as the PI teeth for the detection of the gingival sulcus depth with a blunt periodontal probe. The average value was taken as individual SPD. ③ SBI: the 4 incisor teeth at the lower jaw were selected as the PI teeth for the observation of gingival sulcus bleeding before and after the orthodontics. The average value was taken as an individual score. The specific scoring criteria were as follows: 5 points for obvious gingival swelling with a change in color and bleeding after probing; 4 points for severe gingival inflammation and swelling with a change in color and blood from the gingival sulcus after probing; 3 points for moderate gingival inflammation with blood from the gingival sulcus after gentle probing; 2 points for mild gingival inflammation with petechial hemorrhage when the gingival sulcus was probed slightly; 1 point for minor inflammation of gingival border and papillae gingival with no blood from the gingival sulcus after gentle probing, and 0 points for normal gingival border and papillae gingival when observed visually, and no blood when gently probed. ④ PLI: plaque staining was performed using the modified Turesky method, and the scores were assigned based on the plaque area. The average value of all the tested teeth was taken as the final individual score. The scoring criteria were as follows: 5 points for bacterial plaque coverage >2/3 of the facing, 4 points if it was equivalent to 1/3-2/3 of the facing, and 3 points if the plaque width exceeded 1 mm at the dental cervix but the coverage was less than 1/3 of the facing, 2 points if the if the plaque width was no greater than 2 mm at the dental cervix, 1 point if there was spotted plaque on the gingival border at the dental cervix, and 0 points for no plaque on the facing.

(3) The scoring criteria for evaluating patient satisfaction after the malocclusion orthodontics [11]: a questionnaire was designed by the department for the investigation and covered 5 items, including language function, convenience, chewing function, fixation function, aesthetics, and comfort. Each item was scored between 0 and 10, and the degree of satisfaction was positively correlated with the score.

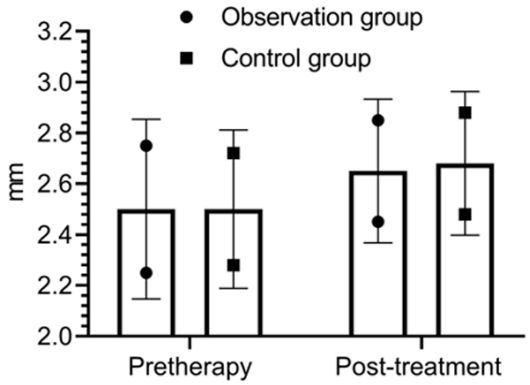


**Figure 2.** Comparison of the SPD in the two groups before and after treatment. The OG and CG demonstrated no statistical differences in terms of the SPD before or after the treatment (P>0.05).

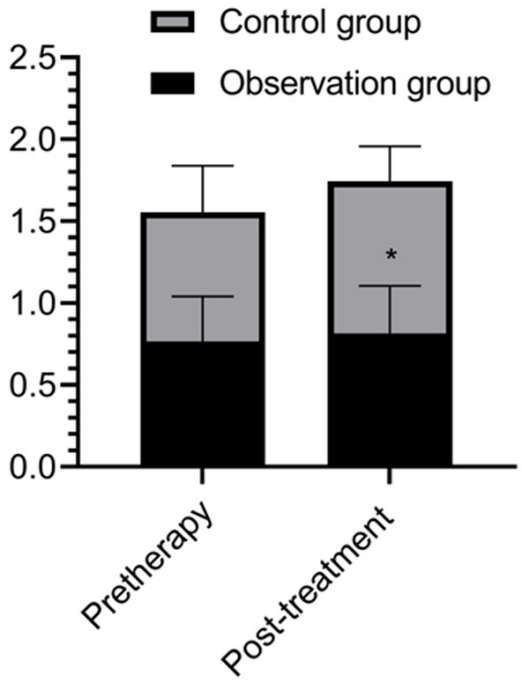


**Figure 3.** Comparison of the SBI before and after treatment in the two groups. While no significant difference was observed between the two groups before the treatment (P>0.05), the OG reported a lower SBI as compared with the CG (P<0.05). * indicates P<0.05 as compared with the CG.

(4) The orthodontic times of tilted teeth and transpositioned teeth were compared between the two groups.

(5) Adverse reactions: the two groups were compared in their adverse reactions during the treatment.

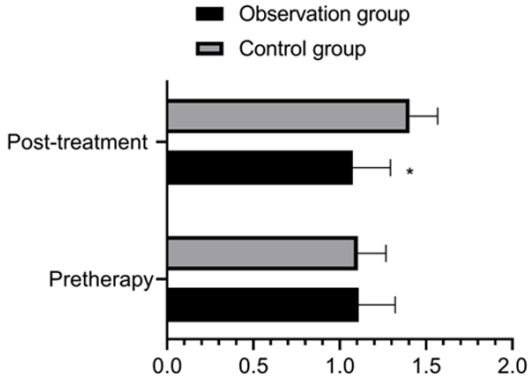


**Figure 4.** Comparison of the PLI before and after treatment in the two groups. In terms of the PLI, no statistical difference was demonstrated between the two groups before the treatment, but after the treatment, the PLI was lower in the OG compared with the CG (P<0.05). * indicates P<0.05 as compared with the CG.

*Statistical analysis*

The statistical analysis was performed using SPSS 22.0. In the case of numerical data expressed as the mean ± standard deviation, the comparisons were carried out using independent-samples T tests for the data which were normally distributed, and Mann-Whitney U tests for the data which were not normally distributed, and paired tests for the pre-and-pro comparisons within a group; in the case of nominal data expressed as [n (%)], the comparisons were carried out using $X^2$ tests for the intergroup comparison. For all statistical comparisons, the significance was defined as $P<0.05$.

## Results

*Comparison of the clinical data in the two groups*

Between the OG and the CG, no statistical differences were observed in terms of the clinical data such as gender, age, course of disease, or malformation type ($P>0.05$, **Table 1**).

*Comparison of the clinical efficacy in the two groups*

The OG yielded a total effective rate of 96.15%, with 32 markedly effective, 18 effective, and 2 ineffective cases, a rate that was higher than the 74.51% in the CG, which had 21 markedly

**Table 3.** Comparison of the degree of satisfaction after malocclusion orthodontics in the two groups ($\bar{x}$ ± s, Score)

| Group | Language function | Convenience | Chewing function | Fixation function | Aesthetics and comfort |
|---|---|---|---|---|---|
| CG (n=51) | 5.12±0.28 | 6.15±0.52 | 5.21±0.18 | 5.42±0.48 | 5.29±0.36 |
| OG (n=52) | 8.25±0.88* | 9.15±0.28* | 8.55±0.28* | 8.29±0.27* | 8.36±0.18* |
| *t* | 24.225 | 36.551 | 71.857 | 37.493 | 54.898 |
| *P* | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Not: *indicates P<0.05 as compared with the CG.

**Table 4.** Comparison of the orthodontic times of the tilted teeth and transpositioned teeth in the two groups ($\bar{x}$ ± s, weeks)

| Group | Orthodontic time of transpositioned teeth | Orthodontic time of tilted teeth |
|---|---|---|
| CG (n=51) | 31.25±2.52 | 28.98±5.16 |
| OG (n=52) | 15.12±1.08* | 15.02±1.06* |
| *t* | 42.363 | 19.104 |
| *P* | 0.000 | 0.000 |

Note: Compared with the control group, **P*<0.05.

**Table 5.** Comparison of the incidence of adverse reactions in the two groups [n (%)]

| Group | n | Endodontitis | Caries | Oral mucosa injury |
|---|---|---|---|---|
| CG | 51 | 15 (29.41) | 12 (23.53) | 14 (27.45) |
| OG | 52 | 1 (1.92)* | 2 (3.85)* | 0 (0.00)* |
| $X^2$ | | 14.828 | 8.494 | 16.829 |
| *P* | | 0.000 | 0.004 | 0.000 |

Not: *indicates P<0.05 as compared with the CG.

effective, 17 effective, and 13 ineffective cases (*P*<0.05, **Table 2**).

*Comparison of the PI before and after the treatment*

Before the treatment, the GI, SPD, and SBI were (0.62±0.15), (2.25±0.96) mm and (0.57±0.15) in the OG and (0.63±0.13), (2.28±0.92) mm and (0.59±0.13) in the CG (P>0.05). After the treatment, the three indexes rose insignificantly to (0.70±0.09), (2.45±0.18) mm and (0.61±0.21) and in the OG, (0.69±0.08), (2.48±0.15) mm and (0.78±0.33) in the CG respectively (P>0.05, **Figures 1**-**3**).

As an exception, the PLI dropped in the OG from (0.96±0.23) to (0.92±0.15), but it rose in the CG from (0.99±0.21) to (1.29±0.45) (P<0.05, **Figure 4**), but no significant difference was observed between the two groups before the treatment.

*Comparison of the satisfaction after malocclusion orthodontics in the two groups*

Our comparison of the 2 groups found higher scores for language function, convenience, chewing function, fixation function, aesthetics and comfort in the OG after the treatment (*P*<0.05, **Table 3**).

*Comparison of the orthodontic times of tilted teeth and transpositioned teeth in the two groups*

The observed orthodontic times of tilted teeth and transpositioned teeth in the observation group were shorter than they were in the control group (*P*<0.05, **Table 4**).

*Comparison of the adverse reactions in the two groups*

During the treatment, the incidences of endodontitis, caries, and oral mucosa injuries were 1.92%, 3.85% and 0.00% in the OG, and 29.41%, 23.53% and 27.45% in the CG, which indicated a significant difference between the 2 groups (*P*<0.05, **Table 5**).

*Changes before and after the fixed and removable orthodontic treatment in juveniles*

Before the fixed orthodontic treatment, the upper and lower dentition, the maxillary dentition, and the anterior dentition were crowded. After the fixed orthodontic treatment, neat dentition could be observed from the frontal occlusion photo after the orthodontics. Before the removable orthodontic treatment, anterior crossbites with abnormal overbites and coverage could be observed from the lateral position film, the panoramic film, and the left and right

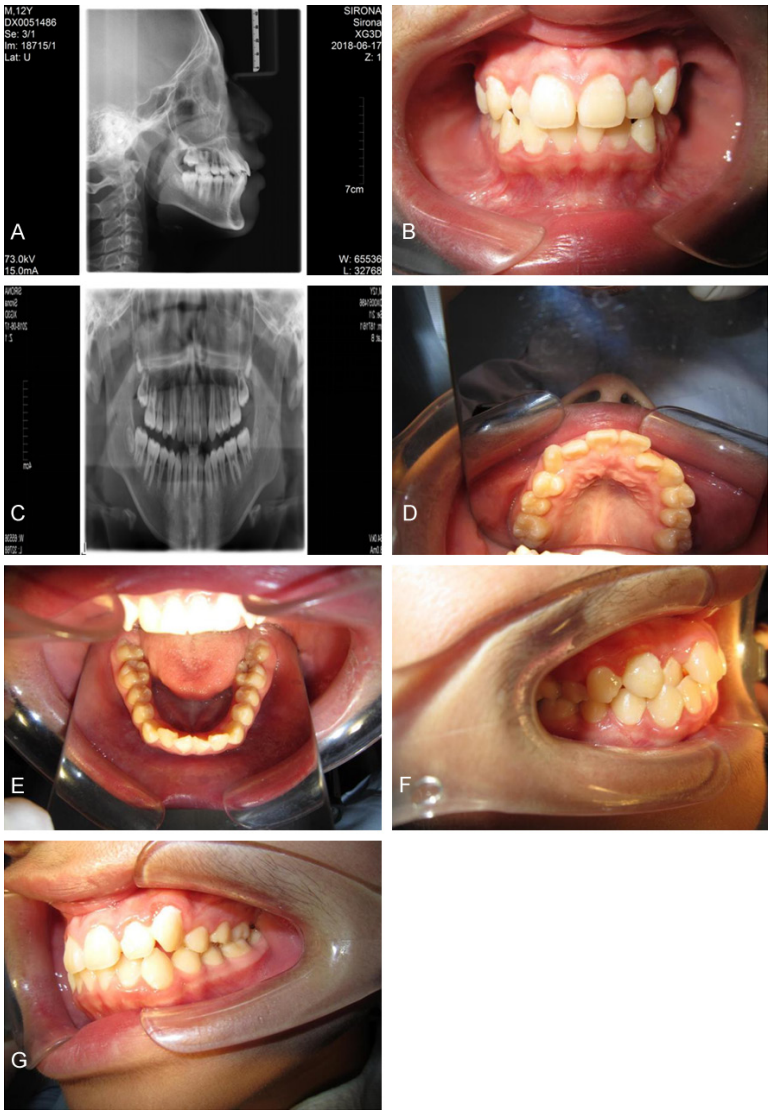

**Figure 5.** Before fixed orthodontics in juveniles. A. Lateral position; B. Front view of inside the mouth, with the crowded upper and lower dentition being observed; C. Panoramic view of the oral cavity; D. Photo of the maxillary dentition, with the crowded maxillary dentition being observed; E. Photo of the mandibular dentition, with the crowded anterior dentition being observed; F. Right occlusion photo; G. Left occlusal photo.

occlusal film. After the removable orthodontic treatment, it can be observed that the anterior crossbite was disengaged with a normal overbite and coverage from the frontal occlusion photo (**Figures 5**-**8**).

## Discussion

Clinically, malocclusion involves a complicated pathogenesis. Its impact on periodontal health and oral aesthetics makes timely and effective treatment an urgent demand [12]. Many methods are available in the clinic, including preventative orthodontics, interceptive orthodontics, general orthodontics and surgical orthodontics in the commonest cases. The common appliances include fixed appliances, removable appliances, and functional appliances [13]. After effective orthodontics, jaw bones and teeth will show a tendency of moving back to their original position. But to ensure their specific positions and the orthodontic effects, a retainer is usually worn to prevent a recurrence of the disease [14, 15].

Most of the previous clinical studies have shown that traditional fixed appliances are highly susceptible to plaque build-up, and as a result, gingival inflammation develops, including gingival bleeding, swelling, etc. [16]. The study found that after the treatment, the patients in the CG experienced a marked elevation in their SPD, GI, SBI, and PLI, which may be attributed to the destruction of the dynamic environment in the oral cavity due to the use of a fixed appliance. The condition further results in dysbacteriosis and gingivitis. When one wears a fixed appliance, especially an orthodontic arch wire or ligature wire, food stagnation, plaque and soft scale build-up are often observed [17, 18]; furthermore, the fixed appliance also affects the adoption of oral health measures, while the residual bonder at the band edge and the bracket will directly stimulate the gingival tissue and lead to more severe gingival inflammation [19]. In the OG, the elevation of SPD, GI, SBI, and PLI were the result of unsmooth or excessively long invisible fixed appliances, which mechanically stimulate the gums, to which plaque is then attached. The long-time wearing of an invisible

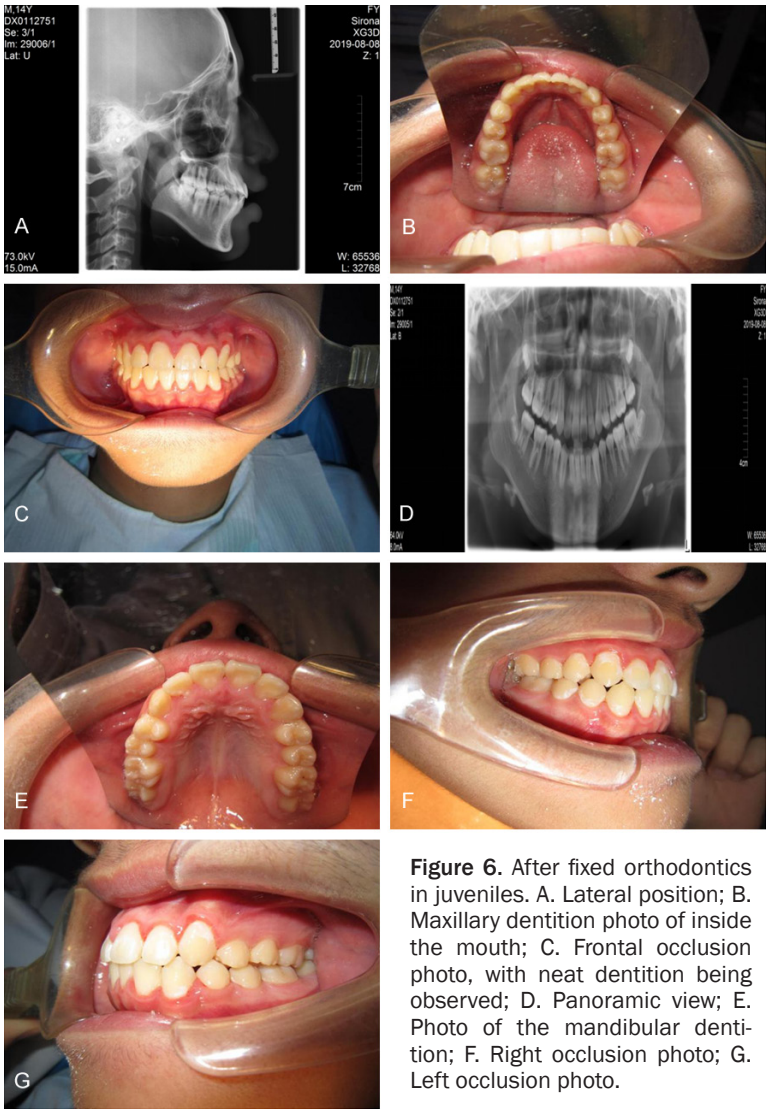


**Figure 6.** After fixed orthodontics in juveniles. A. Lateral position; B. Maxillary dentition photo of inside the mouth; C. Frontal occlusion photo, with neat dentition being observed; D. Panoramic view; E. Photo of the mandibular dentition; F. Right occlusion photo; G. Left occlusion photo.

fixed appliance can have an effect on the self-cleaning ability of the oral cavity. Although there was an increase in the SPD, GI, SBI, and PLI in the OG patients, their SBI and PLI were lower compared with the CG, indicating that regardless of the long-term wearing of bracket-freeing fixed appliances, the patients were allowed to take it off during tooth brushing to avoid any possible impact on their oral health measures. In addition, the fixed appliance is bracket free, which makes it more flexible in the regulation of the application of force to prevent supragingival plaque from metaptosis, and reducing its damage to the periodontium [20].

According to the study results, the OG demonstrated higher scores for language function, convenience, chewing function, fixation function, aesthetics and comfort after treatment as compared with the CG ($P<0.05$), indicating that compared with traditional fixed orthodontic treatment, bracket-free orthodontic treatment is more advantageous in terms of the patients' satisfaction. The underlying reasons may be that the in the bracket-free orthodontic treatment, the fixed appliance is made by the pressed film technology in consideration of the parameters of the materials for the design of the displacement to achieve an accurate control over the orthodontic force [21, 22]. Compared to traditional fixed orthodontics, the bracket-freeing invisible fixed appliance is more aesthetic as it is made of transparent materials [23]; also, it shortens the chairtime and extends the interval of return visits to save time both for the doctor and the patient. For patients with tight or noctis odontoprisis, the invisible fixed appliance covers the facies masticatoria dentis as a protective barrier [24, 25]. In addition, it attaches to the teeth closely and maintains the same form with the teeth to avoid any stimulation on the soft and hard tissues on the oral cavity, and it improves comfort. In addition, during the treatment with invisible fixed appliances, the patients' foreign body sensation in the oral cavity is reduced, and the removable fixed appliance for oral cleaning purposes can result in reduced incidences of adverse reactions such as endodontitis, caries, and oral mucosa injury [26]. In this study, the incidences of endodontitis, caries, and oral mucosa injury were 1.92%, 3.85% and 0.00% in the OG, 29.41% and 3.53% and 27.45% in the CG ($P<0.05$), which further demonstrates the safety of the bracket-free invisible fixed appliance.

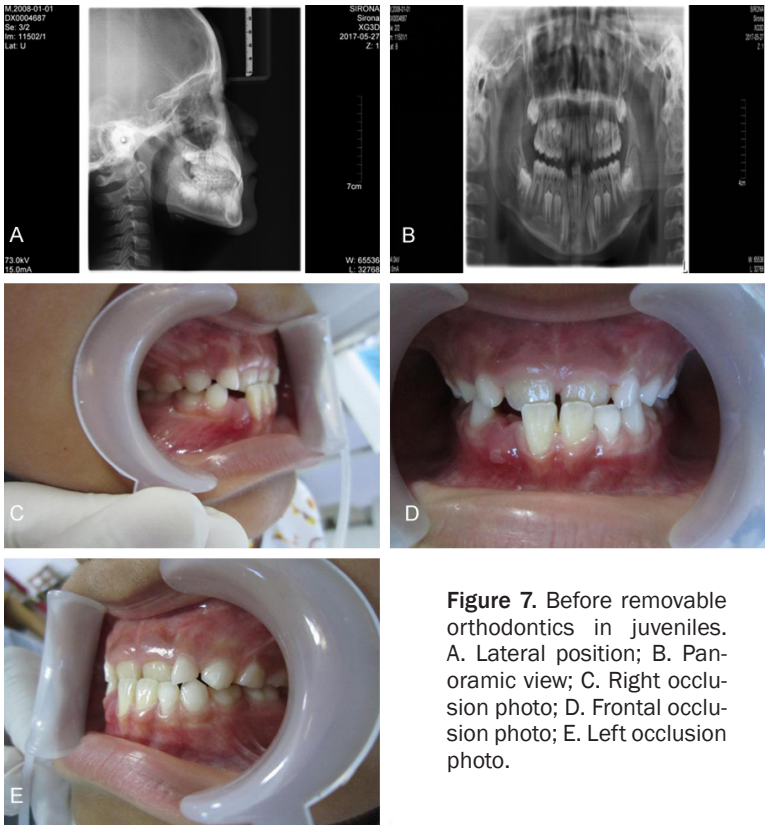


**Figure 7.** Before removable orthodontics in juveniles. A. Lateral position; B. Panoramic view; C. Right occlusion photo; D. Frontal occlusion photo; E. Left occlusion photo.

**Figure 8.** Frontal occlusion photo after removable orthodontics in juveniles. It shows that the anterior crossbite was disengaged with a normal overbite and coverage.

In conclusion, the bracket-free orthodontic treatment may achieve a better efficacy in children with malocclusion orthodontics when compared with the traditional fixed orthodontic treatment since it can maintain periodontal health, improve patients' satisfaction, and reduce the incidence of adverse reactions during treatment.

However, this study included only a small cohort, and placed little emphasis on the long-distance controlling of root movement or the elaborate adjustment of teeth. In the future, an in-depth study based on a larger sample size is necessary.

## Disclosure of conflict of interest

None.

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