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Original Article

The effects of bracketless invisible orthodontics on the PLI, SBI, SPD, and GI and on the satisfaction levels in children with malocclusions

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Abstract: Objective: The purpose of this study was to investigate the effects of bracketless invisible orthodontics on the plaque index (PLI), the sulcus bleeding index (SBI), the gingival sulcus probing depth (SPD), and the gingival index (GI) in children with malocclusions and on their families' satisfaction with the orthodontic treatment. Methods: The baseline data of 113 children with malocclusions were retrospectively collected and divided into two groups according to the orthodontic mode each child underwent. Group A was treated with traditional fixed braces, and Group B was treated with bracketless invisible orthodontics. The clinical efficacy, the satisfaction, the PLI, the SBI, the SPD, and the GI, the tumor necrosis factor-α (TNF-α), interleukin-6 (IL-6), and the interleukin-2 (IL-2) levels, the occurrence of adverse reactions, the COHIP (oral health-related quality of life scale, Chinese Version), and the changes in oral chewing function were compared between the two groups. Results: The total effective rate in group B was 96.49%, higher than the 69.64% in group A (P<0.05). The total satisfaction rate in group B was 98.25%, higher than the 69.64% in group A (P<0.05). Compared with group A, group B had higher PLI, SBI, SPD, and GI levels after the treatment (P<0.05), lower of TNF-α and IL-6 levels, and higher IL-2 levels (P<0.05). The quality of life and the chewing function scores in group B were higher than they were in group A (P<0.05). The incidence rate of adverse events in group B was 5.26%, lower than the 17.86% in group A (P<0.05). Conclusion: The efficacy of bracketless invisible orthodontic treatment in children with malocclusions is higher than it is using traditional fixed orthodontic treatment, as it helps improve their chewing function, periodontal health, and quality of life, and helps reduce the inflammatory factor levels and improves their satisfaction with the orthodontic treatment.

Keywords: Orthodontic treatment, malocclusions, invisible bracketless invisible orthodontics, traditional fixed braces, quality of life, periodontal health

Introduction

Malocclusion is a common oral disease [1]. The etiology of malocclusion is somewhat controversial, but, simply put, it is multifactorial, with its influences being both genetic and environmental, such as bad oral habits leading to an abnormal jaw position, shape and size, an abnormal occlusal relationships between the upper and lower dental arches, irregular teeth arrangements or facial deformities, etc. [2]. The pathogenesis of malocclusion is complex and may be triggered by a single mechanism or single factor, or it may be the result of multiple mechanisms or a combination of factors [3]. Failure to provide timely orthodontic treatment can result in abnormal cranio-maxillofacial development and affect the oral health, function, and cosmetic appearance of a child [4].

Early orthodontic treatment is one of the most effective ways to treat pediatric malocclusion. Orthodontic targets are achieved using orthodontic devices. While the craniofacial growth of children has great potential, by eliminating the risk factors that are not conducive to the normal development of the face, jaw and teeth, the aesthetics of the face, oral function, and health can be effectively improved [5, 6]. A study showed that, using traditional fixed orth-

odontic treatment, it is difficult to obtain ideal clinical results [7]. This treatment option affects not only periodontal health, but it also has an impact on tooth brushing, worsening the degree of inflammation in the gingival tissue [8]. Invisalign without brackets is a comfortable and discreet form of orthodontic treatment that makes full use of multidisciplinary knowledge from computer science, rapid prototyping, dentistry, and biomedicine [9, 10]. This treatment transforms the state of the malocclusion into a three-dimensional digital image using a computer, accurately reflecting the state of the dental model and ensuring minimal deviation [11]. Meanwhile, the technology can determine biomechanical outputs and feasibility and assist the dentist in analyzing the tooth movement patterns.

Invisalign has been widely used in orthodontic treatment in the United States since the end of the last century, with many advantages such as an invisible appearance, comfort, and flexibility, and it has been gradually adopted worldwide [12]. China independently developed the technology of Invisalign in 2003 and gradually applied it to clinical practice [13]. In the past, the traditional fixed orthodontic method was usually used to treat children with malocclusions, but there were significant limitations. In the view of this, in the present study, bracketless invisible orthodontic treatment was used to treat malocclusions, and the efficacy was compared with the efficacy of traditional, fixed orthodontic treatment. The advantages of this treatment were evaluated from the PLI, SBI, SPD, and GI, the patient satisfaction, the adverse reactions, and other aspects, and it is significantly innovative and feasible.

Materials and methods

Baseline data

The clinical data of 113 children with malocclusions in our hospital were retrospectively collected and divided into two groups on the basis of the orthodontic treatment modality each child was treated with. There were 56 children in group A treated with traditional fixed orthodontic treatment and 57 children in group B treated with Invisalign. (1) Inclusion criteria: the informed consent forms were signed by the children's parents; children who had no contraindications to orthodontic treatment; children who had no serious liver, kidney, heart, or other organic diseases; children undergoing their first orthodontic treatment; children who met the diagnostic criteria of malocclusion. This study was approved by the ethics committee of Hangzhou Fuyang Hospital of Traditional Chinese Medicine. (2) Exclusion criteria: midway withdrawal, the presence of other serious oral diseases, cognitive and psychiatric disorders, severe systemic diseases, severe dental crowding, the presence of adverse oral habits, and a history of orthodontic treatment.

Methods

Group A: Before the orthodontic treatment, all the children underwent routine oral X-ray examinations and an ultrasonic cleaning of their oral cavities. Straight wire brackets were used for the orthodontic treatment. During the treatment, the teeth surfaces were first dried and moistened, then they were acid etched, and the brackets were cemented in place after airbrush rinsing and blow-drying. The irregularities and overcrowding of the teeth were corrected using wire arches, and the parents were advised to bring their children to the hospital for a follow-up visit once a month after the treatment was completed. After 6 months of treatment, the children began to wear retainers, and the medical staff instructed the children to use soft-bristled toothbrushes and to brush their teeth ≥3 times a day.

Group B: Before the orthodontic treatment, all the children were subjected to routine oral X-rays to determine the type of deformity each had, and then a customized treatment plan was developed, making full use of computerized three-dimensional imaging technology to produce bracketless invisible appliances, made of transparent polymer materials. The parents were instructed to bring their children to the hospital once a month for a re-examination and to carefully observe their tooth movement, and if necessary, jaw adjustment and adhesion attachments were done. The appliances were replaced every two weeks.

Outcome measurement

Evaluation criteria for efficacy [14]: If a deep anterior overbite was completely restored to normal, and the teeth were aligned properly, it was considered effective. If a deep anterior

Table 1. Comparison of the baseline data [n (%)]/($\bar{x}$ ± s)

Baseline data		Group A (n=56)	Group B (n=57)	t/X^2	P
Gender (cases)	Male	39 (69.64)	42 (78.95)	0.227	0.634
	Female	17 (30.36)	15 (26.32)		
Age (years)		9.48±1.08	9.52±1.03	0.202	0.841
Types of malocclusion					
Angle Class I		31 (55.36)	32 (56.14)	0.007	0.933
Angle Class II		25 (44.64)	25 (43.86)		

Table 2. Comparison of the clinical efficacy [n (%)]

Grouping	Cases	Improvement	Effective	Ineffective	Total effective rate
Group A	56	20 (35.71)	19 (33.93)	17 (30.36)	39 (69.64)
Group B	57	32 (56.14)	23 (40.35)	2 (3.51)	55 (96.49)*
X^2					14.558
P					0.000

Note: *indicates a comparison with group A. P<0.05.

overbite was improved, and the teeth were basically aligned properly, it was considered an improvement. If a deep anterior overbite was not improved, and the teeth were still not aligned properly, it was considered ineffective. Total effect = Effective + Improvement.

Orthodontic satisfaction [15]: After the orthodontic treatment, the children and their parents were surveyed to determine their satisfaction, including factors such as speech function, chewing function, retention function, and aesthetic comfort, covering 0-100 points. Scores ≥90 points indicated very satisfied, scores of 60-89 points indicated basic satisfaction, and scores of <60 points indicated unsatisfactory. Total satisfaction = Basic satisfaction + Very satisfaction.

Periodontal indices [16]: Before and after the treatment, the two groups were compared in terms of their periodontal indices, including the plaque index (PLI), the sulcus bleeding index (SBI), the gingival sulcus probing depth (SPD), and the gingival index (GI).

Inflammatory factors: The gingival fluid, TNF-α, IL-6, and IL-2 levels were measured using enzyme-linked immunosorbent assays in the two groups strictly according to the assay kit's instructions.

Quality of life [17]: Before and after the treatment, the COHIP was used to evaluate the quality of life, including self-image, school environment, functional health, socio-emotional health, and oral health, with a total of 34 questions. Each question was evaluated using a 0-4 Likert scale, with a total possible score of 136 points. A higher score indicated a higher quality of life.

Oral chewing function [18]: The oral chewing function of the two groups was evaluated by having the children eat gelatin, and the oral chewing effectiveness was proportional to the absorbance value.

The occurrences of adverse reactions were compared between the two groups.

Statistical analysis

SPSS 22.0 was used for the data analysis. The mean ± standard deviation was used for the measurement data, and t tests were used for the normally distributed data, while Mann-Whitney U tests were used for the non-normally distributed data. [n (%)] was used for the count data, and X^2 tests were used for the comparisons of the count data between the groups. P<0.05 indicated a statistically significant difference.

Results

Comparison of the baseline data

There were no significant differences in terms of gender, age, or type of malocclusion between the two groups (P>0.05) (**Table 1**).

Comparison of the clinical efficacy

There were 20, 19, and 17 children with effective, improved, and ineffective results respectively in group A, and 32, 23, and 2 children respectively in group B. The effective rate of group B was higher than the effective rate of group A (P<0.05) (**Table 2**).

Comparison of the satisfaction

The total satisfaction rate with the treatment was 98.25% in group B, which was higher than the 69.64% in group A (P<0.05) (**Table 3**).

Table 3. Comparison of the satisfaction between the two groups

Grouping	Cases	Totally satisfied	Basically satisfied	Unsatisfactory	Total satisfaction rate
Group A	56	16 (28.57)	23 (41.07)	17 (30.36)	39 (69.64)
Group B	57	42 (73.68)	14 (24.56)	1 (1.75)	56 (98.25)*
X^2					17.257
P					0.000

Note: *indicates a comparison with group A. *P*<0.05.

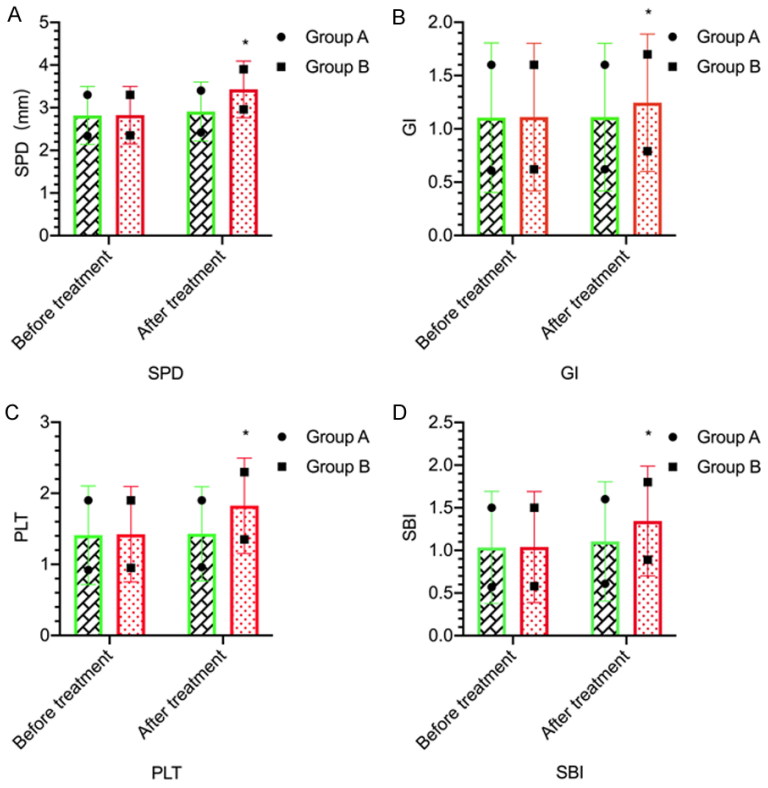

Figure 1. Comparison of the periodontal indices between the two groups. A: SPD; B: GI; C: PLT; D: SBI. * indicates a comparison with group A, *P*<0.05.

Comparison of the periodontal indices

Compared with the pre-treatment levels, the PLI, SBI, SPD and GI levels were increased in both groups (*P*<0.05). They were higher in group B than they were in group A (*P*<0.05) (**Figure 1**).

Comparison of the inflammatory factors

After the treatment, group B showed lower TNF-α and IL-6 levels and higher IL-2 levels than group A (*P*<0.05) (**Figure 2**).

Comparison of the quality of life and oral chewing function scores

The quality of life and oral chewing function scores were improved after the treatment in both groups (*P*<0.05). Compared with group A, the quality of life and oral chewing function scores were higher in group B after the treatment (*P*<0.05) (**Figure 3**).

Comparison of the occurrence of adverse reactions

The incidence of adverse events was 5.26% in group B, which was lower than the 17.86% in group A (*P*<0.05) (**Table 4**).

Discussion

Malocclusions, which can also be referred to as a dentognathic deformity, are a facial, jaw, and dental deformity that results from a combination of factors, including prognathism, anterior crossbite, large diastema, deep overbite, torsion of the teeth, and tooth crowding [19]. Malocclusion, alongside periodontal disease and caries as the three major oral diseases, have a serious impact on the oral health of modern people [20]. Meanwhile, it is also an urgent global health challenge to be solved [21].

With the enhancement of people's awareness of oral health, more and more parents are aware of the harmful effects of malocclusion, and they are eager to improve their children's oral health and teeth and facial aesthetics through orthodontic treatment [22]. Modern orthodontic treatment not only stresses the predictability of outcomes, it also emphasizes the improvement of the concealment, comfort, and aesthetics of the braces. Traditional fixed

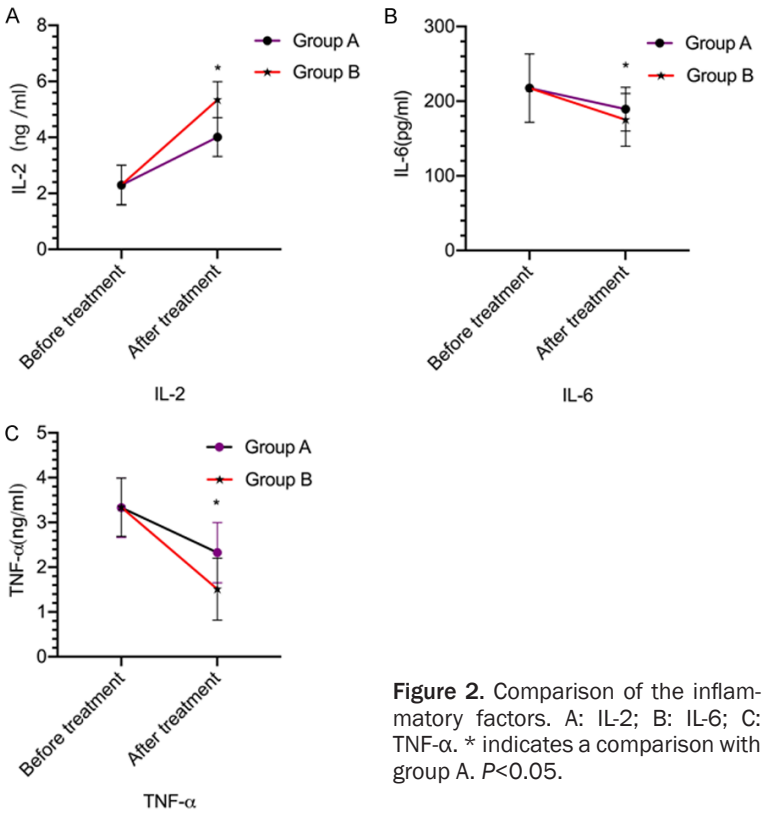

Figure 2. Comparison of the inflammatory factors. A: IL-2; B: IL-6; C: TNF-α. * indicates a comparison with group A. *P*<0.05.

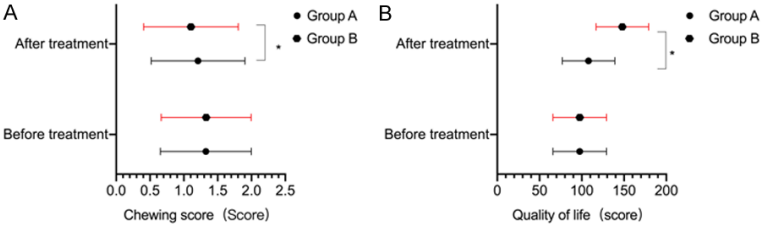

Figure 3. Comparison of the oral chewing function and quality of life scores between the two groups. A: Oral chewing function scores; B: Quality of life scores. * indicates a comparison with group A. *P*<0.05.

Table 4. Comparison of the occurrences of adverse reactions [n (%)]

Grouping	Cases	Gingivitis	Dental caries	Oral mucosal injury	The incidence rate
Group A	56	3 (5.36)	4 (7.14)	3 (5.36)	10 (17.86)
Group B	57	1 (1.75)	1 (1.75)	1 (1.75)	3 (5.26)*
X^2					4.401
P					0.036

Note: *indicates a comparison with group A. *P*<0.05.

orthodontic treatment was previously used in clinical practice to treat malocclusions, i.e., applying pressure through a straight wire arch to guide tooth movement and thus play an orthodontic role [23]. This method could straighten the teeth, but it could also cause great pain and inconvenience in the child's daily life. The present study used bracketless orthodontic treatment to address the limitations of the traditional fixed orthodontic method. The results showed that the total treatment efficiency, the orthodontic satisfaction, and the post-treatment periodontal indices of group B were higher than they were in group A (*P*<0.05), suggesting that bracketless invisible orthodontic treatment can be more effective than traditional fixed orthodontic treatment, so it helps improve periodontal health. Sun et al. [24] found that the speech function, convenience degree, chewing function, retention function, and aesthetic comfort scores in the observation group were higher than they were in the control group after the treatment, which was highly consistent with the results of this study. The underlying mechanism may be that the braces of the bracketless invisible orthodontics are made of transparent polymer material, so they are concealed and aesthetically pleasing, without archwires and brackets. Since the braces are basically invisible, they cater to the aesthetic and comfort requirements to the greatest extent. Second, the pressure of a bracketless invisible appliance is mainly sourced from the resilience of the deformation of the thermoplastic materials, which brings a higher aesthetic perception, thus improving the orthodontic satisfaction in the child and his/her parents. During the application of traditional

fixed braces, the treatment efficacy will be affected by the bracket and the archwires, with low comfort and aesthetic levels. Third, the quality of life and oral chewing function in group B were better, and the incidence of adverse reactions was lower than it was in group A. This may be because the bracketless orthodontic appliances are self-worn, and they will barely stimulate the soft and hard tissues of the oral cavity and help maintain oral hygiene, and they will ensure normal oral chewing function, thus improving the quality of life and reducing the incidence of adverse reactions [25]. In addition, group B showed lower TNF-α and IL-6 levels and higher IL-2 levels than group A after the treatment ($P<0.05$). IL-2 is a type of cell growth factor of the immune system, and its decreased level indicates a decrease in the body's immunity. TNF-α, a killing mechanism for cancer cell death, can regulate the verbal and behavioral responses and has anti-infection and anti-tumor effects, and its increased level indicates an inflammatory state [26, 27]. IL-6 mainly mediates the inflammatory response and acts on vascular endothelial cells, and its level is also significantly increased when the organism is in a state of pathological damage. In the study, the TNF-α and IL-6 levels were lower and the IL-2 level was higher in group B after the treatment, suggesting that the inflammation level is improved and the immunity is increased after treatment using the bracketless orthodontic method [28].

In summary, the efficacy of the orthodontic treatment for malocclusions is higher than it is with the traditional fixed orthodontic treatment, as it can improve the chewing function, the periodontal health, and the quality of life, reduce the inflammatory factor levels and increase the satisfaction with the orthodontic treatment.

Limitations: Although this study has made some achievements, only a small number of subjects were included, and there is still a lack of research on controlling the long-distance root movement and the fine adjustment of teeth, so this needs to be further explored by expanding the sample size in the future.

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Disclosure of conflict of interest

None.

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