

Original Article

The effect of orthodontic treatment on temporomandibular joint morphology in adult skeletal class II deep overbite patients

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Abstract: Objective: To explore the morphological changes of the temporomandibular joint (TMJ) in adult patients with skeletal class II deep overbite before and after orthodontic treatment, and to analyze the effect of the orthodontic treatment. Methods: A total of 40 adult skeletal class II deep overbite patients were recruited as the study cohort. For each subject, the morphology and position of the TMJ were determined using cone beam computed tomography. Results: Compared with before the treatment, the morphology of the condyle changed. The maximum cross-sectional area of the condyle in the axial plane and the condyle neck anteroposterior diameter in the coronal plane were reduced. The condylar apex height in the sagittal plane and the anterior condyle oblique inclination increased with statistically significant differences (all $P < 0.001$). There were more patients who showed their condyles moving forward and their condyles in the middle after the treatment compared with before the treatment, and with a statistically significant difference ($P = 0.002$). The morphology of the glenoid fossa changed after the treatment. The articular eminence to the FH plane angle in the sagittal plane and the inclination of the posterior glenoid increased. The total height of the fossa increased with statistically significant differences (all $P < 0.001$). Conclusion: TMJs can be adaptive to reconstruction. Orthodontic treatment shows a favorable efficacy in skeletal class II deep overbite patients.

Keywords: Orthodontic treatment, class II deep overbite, temporomandibular joint, efficacy

Introduction

The skeletal class II deep overbite is currently one of the most common oral malformations. The most common symptoms are convexity, uncovered teeth, retraction underneath the skeleton, and even upper airway stenosis in severe cases. A disorder of the temporomandibular joint (TMJ) is more apparent in patients with skeletal class II deep overbites than in normal people, affecting their facial health and appearance [1]. People now pay more attention to facial beauty in work and life, so an increasing number of patients are willing to undergo orthodontic treatment to change the morphology and position of the condyle and the morphology of the temporomandibular fossa [2]. The morphology of the mandibular joint in patients with skeletal class III deep overbite also changes after orthodontic treatment [3,

4]. However, there are few studies on the effect of the orthodontic treatment on the morphology of the mandibular joint in adult skeletal class II deep overbite patients. Therefore, this study aims to evaluate the morphological changes of the mandibular joint in skeletal class II deep overbite patients after orthodontic treatment using cone-beam computed tomography (CBCT), in order to provide a theoretical basis for the orthodontic treatment of skeletal class II deep overbite.

Materials and methods

Subjects

A total of 40 patients diagnosed with adult skeletal class II deep overbite in our hospital from December 2018 to December 2019 were recruited as the study cohort. This study was approved by the Ethics Committee of our hospi-

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Table 1. General conditions (n=40; $\bar{x} \pm sd$)*

| Category | Before treatment | | After treatment | |
|--|------------------|-------------|-----------------|------------|
| | Left | Right | Left | Right |
| Maximum cross-sectional area of condyle (mm ²) | 98.84±17.12 | 99.11±15.67 | 76.63±9.08 | 74.05±9.34 |
| Condyle neck anteroposterior diameter (mm) | 7.78±1.21 | 8.12±1.34 | 7.34±1.07 | 7.31±0.98 |
| Anterior condyle oblique inclination (°) | 34.01±2.39 | 32.98±3.27 | 35.02±2.43 | 35.32±3.87 |
| Condylar mediolateral diameter (mm) | 18.68±1.19 | 18.82±1.54 | 17.79±1.68 | 17.60±2.32 |
| Condylar apex height (mm) | 18.06±1.96 | 17.79±1.86 | 17.61±1.97 | 18.04±2.25 |
| Articular eminence to the FH plane angle (°) | 29.26±2.67 | 28.15±2.49 | 32.48±1.85 | 33.56±3.06 |
| Total height of the fossa (mm) | 7.72±0.88 | 7.85±0.98 | 8.23±0.79 | 8.48±0.84 |
| Anteroposterior width of the articular fossa (mm) | 15.47±2.14 | 15.21±2.21 | 15.03±2.48 | 15.31±2.31 |
| Inclination of posterior glenoid (°) | 33.21±2.53 | 31.79±3.23 | 36.02±3.31 | 35.57±2.43 |

Note: *indicates measurement data.

Table 2. Morphological changes of the condyle before and after treatment ($\bar{x} \pm sd$)*

| Variable | Before treatment (n=40) | After treatment (n=40) | t | P |
|---|-------------------------|------------------------|-------|--------|
| Maximum cross-sectional area of condyle | 98.73±17.78 | 80.21±15.79 | 15.68 | <0.001 |
| Condyle neck anteroposterior diameter | 8.01±1.43 | 7.64±1.55 | 1.520 | 0.131 |
| Anterior condyle oblique inclination | 33.03±2.89 | 35.41±3.30 | -8.92 | <0.001 |
| Condylar mediolateral diameter | 18.56±2.32 | 17.25±1.92 | 9.72 | <0.001 |
| Condylar apex height | 3.01±1.15 | 3.44±0.90 | -8.69 | <0.001 |

Note: *indicates measurement data.

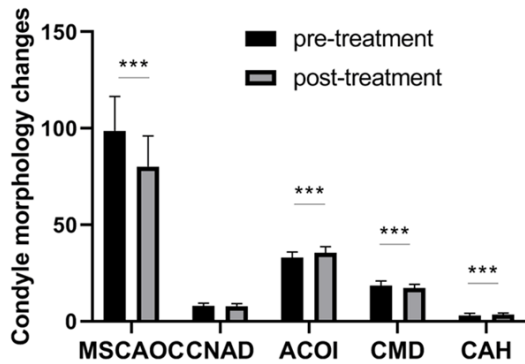


Figure 1. Morphological changes of the condyle before and after treatment. Compared with the pre-treatment morphology, ***P<0.001. MSCAOC: maximum cross-sectional area of the condyle; CNAD: condyle neck anteroposterior diameter; ACOI: anterior condyle oblique inclination; CMD: condylar height mediolateral diameter; CAH: condylar apex height.

tal (ethical approval number: S2020-133). All the patients signed an informed consent form.

The patients were eligible for the study if they were 18 years old or older, if they showed an ABN angle $>4.7^\circ$ and $22^\circ \leq FMA \leq 32^\circ$, if they had no history of orthodontics or other facial surgery, if they had no maxillofacial trauma, joint trauma, TMJ dysfunction, or cleft lip and

palate, if they were mentally healthy and able to use self-locking braces, and if they participated voluntarily and could actively cooperate with the doctors.

Patients were excluded if they were suffering from systemic diseases, if they were pregnant or lactating, or if they had severe dental caries or abrasions.

Methods

In this retrospective study, the subjects were measured for TMJ morphology-related parameters before and after receiving orthodontic treatment. The details of the orthodontic treatment are as follows. The Damon Q self-locking bracket correction system from Ormco, US, was used to put occlusal plates on and to bond self-locking brackets to all the teeth. Nickel-titanium round wires were used for light traction and for further adjustments to get even mandibular teeth.

Measurement methods and the measured items

CBCT was used to measure the morphology and position of each mandibular joint before

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Table 3. Changes in the position of the condyle before and after treatment (n=40; n, %)*

| Variable | Before treatment | After treatment | χ^2 | P |
|-------------------------|------------------|-----------------|----------|-------|
| Condyle in the middle | 40 (50.0%) | 51 (63.8%) | 12.019 | 0.002 |
| Condyle moving forward | 8 (10.0%) | 16 (20.0%) | | |
| Condyle moving backward | 32 (40.0%) | 13 (16.2%) | | |

Note: *indicates count data.

and after treatment. *In vivo* Dental 5 imaging software (Anatomage) was used to reconstruct the scan data. The imaging and measurement were performed in the axial, sagittal, and coronal planes according to the method of Jiang et al. [5].

There were 4 outcome measures. First, the morphology of the condyle was described using the maximum cross-sectional area of the condyle in the axial plane, the condyle neck anteroposterior diameter in the axial plane, the anterior condyle oblique inclination in the sagittal plane, the condylar apex height in the sagittal plane, and the condylar mediolateral diameter in the coronal plane. Second, the position of the condyle was described using the condyle position in the sagittal plane (posterior joint space area/anterior joint space area). Values of -0.25-0.25 indicated that the position of the condyle was in the middle, values >0.25 indicated that the condyle moved forward, and values <-0.25 indicated that the condyle moved backward. Third, the position of the glenoid fossa was described using the articular eminence to the FH plane angle in the sagittal plane, the total height of the fossa in the coronal plane, the anteroposterior width of the articular fossa in the coronal plane, and the inclination of the posterior glenoid in the coronal plane. Finally, the patients' satisfaction rates after the surgery were evaluated and classified into one of three levels (satisfaction, basic satisfaction and dissatisfaction). The treatment satisfaction rate was defined as: treatment satisfaction rate = (cases of satisfaction + cases of basic satisfaction)/total number of cases * 100%.

Statistical methods

SPSS 22.0 software was used for the statistical analysis. GraphPad Prism 8 was used to plot the figures. The measurement data that met a normal distribution were expressed as

the mean \pm standard deviation ($\bar{x} \pm sd$). The TMJ morphological measurements on the different sides were processed using independent sample t-tests, and the TMJ morphological measurements before and after the treatment were processed using paired t-tests. The count data were described using composition ratios and processed using chi-square tests, two-sided $\alpha=0.05$. $P<0.05$ was considered statistically significant.

Results

General data

Among the 40 adult patients with skeletal class II deep overbites, 17 were males and 23 were females, aged 22-36 years old, with an average age of 27.9 ± 4.4 years old. There was no statistically significant differences in the morphology or positions of the mandibular joints on the left and right sides of the patients before and after the treatment (all $P>0.05$). See **Table 1** for details.

Morphology changes of condyle

After the treatment, the maximum cross-sectional areas of the condyle in the axial plane and the condylar mediolateral diameters in the coronal plane decreased; the condylar apex heights in the sagittal plane and the anterior condyle oblique inclinations increased with statistically significant differences (all $P<0.001$). There were no significant differences in the condyle neck anteroposterior diameters before or after the treatment ($P=0.131$). See **Table 2** and **Figure 1**.

Change of condyle position

The positions of the condyle in the sagittal plane changed significantly before and after the treatment. There were more patients who showed a condyle moving forward and a condyle in the middle after the treatment compared with the pre-treatment data ($P=0.002$). See **Table 3** for details.

Morphological changes of the glenoid fossa

After the treatment, the morphology of the glenoid fossa was significantly changed. The artic-

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Table 4. Morphological changes of the glenoid fossa before and after treatment ($\bar{x} \pm sd$)*

| Variable | Before treatment (n=40) | After treatment (n=40) | t | P |
|--|-------------------------|------------------------|--------|--------|
| Articular eminence to the FH plane angle | 28.54±2.42 | 32.18±3.07 | -34.55 | <0.001 |
| Inclination of posterior glenoid | 33.35±2.98 | 35.72±2.55 | -23.62 | <0.001 |
| Total height of the fossa | 7.78±0.89 | 8.31±0.95 | -5.56 | <0.001 |
| Anteroposterior width of the articular fossa | 15.34±3.11 | 15.17±2.87 | 0.823 | 0.342 |

Note: *indicates measurement data.

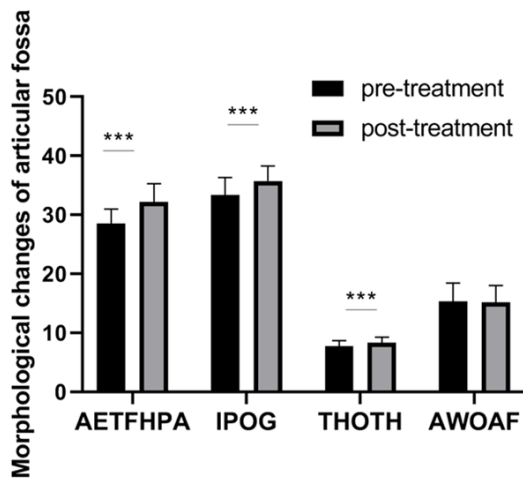


Figure 2. Changes in the glenoid fossa morphology before and after treatment. Compared with before the treatment, ***P<0.001. AETFHPA: articular eminence to the FH plane angle; IOPG: inclination of the posterior glenoid; THOTF: total height of the fossa; AWOAF: anteroposterior width of the articular fossa.

ular eminence to the FH plane angle, the inclination of posterior glenoid in the sagittal plane, and the total height of the fossa in the coronal plane increased with statistically significant differences (all P<0.001). The changes in the total height of the fossa in the coronal plane were not significant after the treatment (P=0.342). See **Table 4** and **Figure 2** for details.

Satisfaction rate

After the treatment, 38 patients were satisfied with the treatment, 1 patient was basically satisfied, and 1 patient was dissatisfied, for a treatment satisfaction rate of 97.5%, indicating a high recognition of the efficacy of the orthodontic treatment.

CBCT before and after the orthodontic treatment

After the orthodontic treatment, the articular eminence to the FH plane angle, the inclination of the posterior glenoid, and the total height of

the fossa in the coronal plane increased. The position of the condyle in the glenoid fossa moved from the outer upper back to the middle. So, the patients' facial appearances improved well, with neatly arranged upper and lower teeth and favorable occlusions. The lateral cephalometric images of the class II malocclusions before and after the orthodontic treatment are shown in **Figure 3**.

Discussion

Skeletal class II deep overbite is a common clinical malformation with a complicated pathogenesis. The prevalence of skeletal class II deep overbite in China is about 20%, and the prevalence in adolescents is 23% [6]. The clinical manifestation of skeletal class II deep overbite is mandibular retraction, which not only affects the normal function of the mandible but also the appearance. In addition, skeletal class II deep overbite patients often have posterior upper condyle displacement and are prone to TMJ diseases due to the strong masticatory muscles [7]. One study found that patients with skeletal class II deep overbites often also suffer from tooth wear and periodontal trauma, which affects chewing and also causes adverse psychological effects on the patients [8]. For adult patients, the main treatment method is orthodontic treatment. Yu et al. found that the patients' facial morphology improved well, and their quality of life also improved after the orthodontic treatment [9, 10].

The indexes involved were all obtained using CBCT. A previous study found that compared with X-ray imaging and traditional spiral CT, CBCT showed a promising feasibility and accuracy in TMJ measurement, and it was able to ensure the accuracy of the research results [11].

This study found no difference in the morphological measurements on the left and right

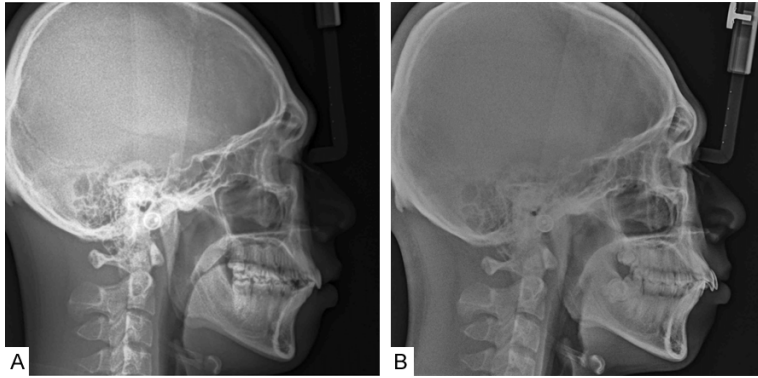


Figure 3. The lateral cephalometric images before and after orthodontic treatment. A: The lateral cephalometric images after the orthodontic treatment; B: The lateral cephalometric images before the orthodontic treatment.

sides of the TMJs, indicating that the orthodontic treatment did not affect the symmetry of the TMJs. This is consistent with previous results [12]. The shapes of the patients' left and right TMJs are basically symmetrical. One possible reason is that the TMJ is a linked joint, and the left and right sides often have the same movement, so they are often symmetrical.

The results of this study showed that the maximum cross-sectional area of the condyle decreased from 98.73 mm² (before treatment) to 80.21 mm² (after treatment) in the skeletal class II deep overbite patients, which is basically consistent with the results from the study of Shi [13]. The inner and outer diameters of the condyle neck decreased from 18.56 mm (before treatment) to 17.25 mm (after treatment), which is in line with the results from the study of Li et al. [14]. The condylar apex height and the anterior condyle oblique inclination increased from 3.01 mm and 33.03° (before treatment) to 3.44 mm and 35.41° (after treatment), respectively, as they did in the study of Zhu et al. [15]. One possible reason is that the adult condyle can still be adapted to remodeling [16]. After the orthodontic treatment, the patient's occlusion changed, and the condyle underwent adaptive changes. In skeletal class II deep overbite patients, the articular eminence to the FH plane angle, the total height of the fossa, and the inclination of posterior glenoid increased after the treatment compared with before the treatment. This is basically consistent with the research results from Wang and Qin et al. [17, 18]. The increased TMJ load of the patients after the treatment and the reconstruction of the glenoid fossa are possible reasons [19-22]. After the orthodontic

treatment, the position of the condyle in the glenoid fossa moved from the outer upper back to the middle. The proportion of the posterior condylar displacement decreased from 40% to 16.2%, and the position in the middle increased from 50.0% to 63.8%, which is consistent with the studies of Carlton et al. and Liu et al. [23, 24]. The adaptive reconstruction of the TMJ after the orthodontic treatment is a possible reason.

This study also has certain limitations. The study cohort was small, and the cohort ranged in age from 22 to 36 years old, so there may be a selection bias, which could have a certain influence on the extrapolation of the research results. We plan to continue to recruit patients that meet the selection criteria in the future diagnostic and treatment process to expand the sample size of the study.

In summary, orthodontic treatment for skeletal class II deep overbite can help the adaptive reconstruction of the TMJ, and the position of the condyle in the glenoid fossa changes from relatively outer and upper to middle, suggesting a favorable clinical effectiveness.

Disclosure of conflict of interest

None.

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