Original Article

Comparison of two different therapeutic approaches for skeletal Class II patients with temporomandibular degenerative joint disease

Xueyan Qin[a]; Yuyan He[b]; Shouyu Zhang[b]; Ni Jin[b]; Zhi Yang[c]

ABSTRACT

Objectives: To compare two different therapeutic approaches for skeletal Class II patients with temporomandibular degenerative joint disease.

Materials and Methods: A total of 47 patients were included in this study. Group anterior repositioning splint (ARS) was treated with temporomandibular joint (TMJ) disc surgery followed by an ARS and camouflage orthodontic treatment. Group stabilization splint (SS) was treated with an SS followed by orthodontic treatment combined with orthognathic surgery. Cephalometric analysis of lateral radiographs and measurements of condylar height were evaluated before and after splints.

Results: In group ARS, mandibular advancement was observed after treatment in 21 of 24 patients (87.5%). The SNB angle increased by an average of $1.40 \pm 1.01°$. The ANB angle, overjet, Wits, and convexity decreased. Facial angle and soft tissue N Vert to pogonion increased. Vertically, MP-FH, MP-SN, y-axis, and vertical ratio decreased and ANS-Me/N-Me and S-Go/N-Me increased, suggesting a counterclockwise rotation of the mandible. In group SS, 18 of 23 patients (78.3%) showed a backward change tendency. The SNB angle reduced by $0.90 \pm 0.93°$. The ANB angle, overjet, Wits, convexity, and y-axis increased. The facial angle and soft tissue N Vert to soft tissue pogonion (ST N Vert to ST pogonion) decreased. Magnetic resonance imaging showed condylar height increased by 1.45 ± 3.05 mm ($P = .002$) in group ARS. In group SS, condylar height change was not consistent.

Conclusions: TMJ disc surgery followed by ARS promoted condylar bone remodeling and regeneration. The SNB angle increased, and the severity of skeletal Class II was improved. The SS enabled the mandible to withdraw backward and revealed a retrognathic but true mandible position. (*Angle Orthod.* 2022;93:49–56.)

KEY WORDS: Class II; TMD; Splint therapy

INTRODUCTION

Temporomandibular disorder (TMD), especially temporomandibular degenerative joint disease (DJD), is always a challenge for orthodontists due to an unstable occlusion and prognosis, nebulous etiology, high prevalence, and frequently concomitant psychological condition.

TMD is an umbrella term for several clinical problems involving the masticatory muscles, temporomandibular joints, and associated orofacial struc-

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tures.[1] DJD is characterized by deterioration of the temporomandibular joint disk along with abrasion and remodeling of TMJ hard tissue and the underlying subchondral bone, resulting in severe sclerosis, disc destruction, and lytic lesions.[2] Based on whether it is accompanied by self-reported pain, DJD can be divided into painless osteoarthrosis or osteoarthritis with pain.[3] DJD is diagnosed when there is a coarse crepitus in the TMJ according to the Diagnostic Criteria for Temporomandibular Disorders. Clinical symptoms include pain, joint sounds, joint stiffness, and restriction of mandibular movement. Previous studies revealed a multifactorial etiology for DJD, including trauma, parafunction, increased friction, joint disturbances, and unstable occlusion.[3] Excessive or prolonged joint loading caused by the aforementioned factors might trigger unbalanced remodeling. The pathologic mechanism for DJD characteristic sclerosis is anabolic bone remodeling to strengthen overloaded trabeculae, whereas bone thickness exceeds the blood supply diffusion limitation for living bone. Therefore, the internal bone core hypermineralizes. When the overloaded trabeculae fractures, a bone resorptive response and subcortical cystic formation appear.

In general, the prevalence of TMD varies from 16% to 59% for symptoms and from 33% to 86% for clinical signs based on different populations and study methods.[3–6] Across multiple population studies, the prevalence of DJD has varied from 2% to 16%, depending on different diagnostic criteria.[2] The incidence of TMJ disc displacement and DJD is high in skeletal Class II patients with a hyperdivergent growth pattern.[7] Studies revealed that the prevalence of skeletal Class II among TMD patients was fourfold that among the general population and that angle Class II occlusal relationships might be associated with joint-related TMD.[8,9] In addition, a study conducted in China showed that 52.4% of female patients with skeletal Class II deformities who underwent orthodontic treatment and subsequent orthognathic surgery were diagnosed with osteoarthrosis.[10] The patients with osteoarthrosis exhibited the smallest S-Go length, highest mandibular angle, and the most retruded mandible with clockwise rotation.[10] This was consistent with another study focused on asymptomatic skeletal patients that reported that osteoarthritis was observed in the joints of 3% of Class I patients, 43% of Class II patients, and 20% of Class III patients.[11] Craniofacial morphology is complex. It was found that the position of the TMJ with respect to the skull was related to the thoracic-lumbar-sacral spine inclination among orthodontic patients. Patients with posterior rotation of the condyle-orbital plane had sagittal Class II and hyperdivergent profiles as well as forward inclination of the spine.[12]

The pathogenesis and the correlation between certain types of malocclusions and TMD could be a chicken-and-egg problem that remains to be elucidated. However, orthodontists cannot avoid the situation in which skeletal Class II patients with TMD present to orthodontic offices in daily practice seeking treatment for their facial profiles and occlusal functions. Therefore, there is an increasing need for orthodontists to take TMJ conditions into consideration in orthodontic treatment planning.

Treatment approaches for TMD can be divided into two major camps. Conservative treatment focuses on symptom improvement and functional recovery, whereas surgical treatment aims at structure reconstruction as a premise for stability. Both approaches are backed by adequate empirical evidence. However, the assessment criteria for most previous studies were based on temporomandibular joint symptomatology, including pain alleviation, maximum mouth opening, and condylar bone remodeling. Orthodontists are more concerned with a stable and true mandibular position, which is undoubtedly the foundation of reasonable orthodontic diagnosis and treatment planning.

The purpose of this study was to compare the effects of condylar remodeling and mandibular position between two different therapeutic approaches for skeletal Class II patients with DJD.

MATERIALS AND METHODS

Patients

This was a retrospective study approved by the local ethics board of Shanghai Ninth People's Hospital, College of Stomatology, Shanghai Jiao Tong University School of Medicine. A sample of 47 young adults aged between 17 and 32 years was collected. They were young adults with DJD and skeletal Class II (mandibular dysplasia) who visited the Center of Craniofacial Orthodontics, Department of Oral and Cranio-maxillofacial Surgery, Ninth People's Hospital to seek treatment between May 2014 and November 2020. The treatment plans were made by the same experienced orthodontist according to the patients' TMJ conditions, degree of Class II, and willingness to accept orthognathic surgery.

The inclusion criteria were as follows: (1) skeletal Class II malocclusion with temporomandibular DJD, (2) age between 17 and 35 years at the initial visit, and (3) treated with either temporomandibular joint disc surgery followed by postoperative anterior repositioning splint (ARS) and then camouflage orthodontics or occlusal stabilization splint (SS) therapy and orthognathic surgery combined with orthodontic treatment.

Patients were excluded from study enrollment if they had (1) trauma history, (2) systemic disease, or (3) incomplete clinical and radiographic records.

Procedure

In group ARS, disc repositioning surgeries were performed for all joints in the Department of Oral Surgery of the hospital by the same experienced doctor with mini-screw anchors through open incisions. Patients started ARS treatment 1 or 2 months after the surgery to keep the mandible in the forward position. The duration of ARS lasted for 4-6 months. After that, patients were reevaluated for camouflage orthodontics or alternative treatment. Magnetic resonance imaging (MRI) and cephalometric imaging were performed before surgery and after ARS therapy. In group SS, occlusal SSs were prescribed to patients for 3-6 months to reveal the true mandible position before the combined treatment of orthodontics and orthognathic surgery. MRIs and cephalometric imaging were performed before and after SS therapy. Cephalometric analysis and measurements of condylar height were evaluated at two timepoints: before treatment/at baseline (T0) and after ARS/SS (T1). A 3.0 T magnetic resonance scanner (Ingenia, Philips Healthcare Systems, Eindhoven, The Netherlands) with a six-channel dS Flex M surface coil receiver was used to perform MRI examinations.

Measurements

The largest section of the condyle MRI image at the closed position was selected, and condylar height was measured using the three-circle method.[13] An internally tangent circle O1 was drawn at the most curved area between the condylar neck and head. The internally tangent circle O2 was drawn at the narrowest section of the condylar neck. Through the circle centers of O1 and O2, the long axis of the condylar neck (y) was determined. Line x was constructed perpendicular to line y and tangent to the condylar outline at point A. Line x' was parallel to line x and tangent to the sigmoid notch. The length between lines x and x' was measured as the condylar height. AutoCAD (Autodesk, Sausalito, CA, USA) software was used to obtain parameter values that were accurate to 0.01 mm (Figure 1).

Lateral cephalometric X-ray images were measured by the Analysis of Shanghai Ninth People's Hospital using Dolphin 11.5 software (Dolphin Imaging, Chatsworth, Calif). The measurements are listed in Tables 1 and 2.

Statistical analyses were performed by IBM SPSS Statistics version 18.0 (IBM Corp., Armonk, NY).

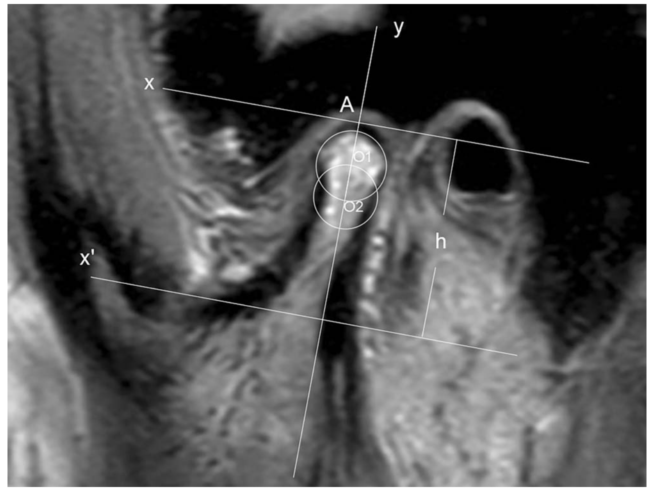

Figure 1. Measurements of condylar height in MRI images.

Paired-sample *t*-tests were used. $P < .05$ was considered statistically significant.

RESULTS

There was no difference in sex between the two groups. However, the mean age was different ($P < .001$): the ARS group was aged 20.38 ± 3.27 years, and the SS group was aged 23.70 ± 4.07 years (Table 3). The severity of the sagittal degree of Class II ($P < .01$) and vertical hyperdivergency ($P < .05$) was different. In the ARS group, before treatment, the average ANB was 7.67°, MP-FH was 33.24°, and MP-SN was 39.89°. In the SS group, before treatment, the average ANB was 9.57°, MP-FH was 38.53°, and MP-SN was 44.16°.

In group ARS, mandibular advancement after treatment was observed in 21 of 24 patients (87.5%). The SNB angle was 72.95 ± 4.09° before treatment and 74.36 ± 4.03° after, yielding an average increase of 1.40 ± 1.01° ($P < .001$). The ANB angle was 7.67 ± 1.42° at T0 and 6.27 ± 1.84° at T1. After disk repositioning and ARS treatment, the ANB decreased by 1.40 ± 0.98° ($P < .001$). Overjet decreased by 2.93 ± 2.00 mm, from 6.92 ± 2.44 mm to 3.99 ± 1.54 mm ($P < .001$). Wits decreased by 2.87 ± 2.23 mm ($P < .001$) (Table 1).

In addition, facial angle (FH-NPo) increased, and convexity (NA-APo) decreased ($P < .001$), also indicating the anteroposterior growth of the mandible. Vertically, MP-FH, MP-SN, and y-axis (SGn-SN) all decreased ($P \leq .01$), suggesting the counterclockwise rotation of the mandible. For facial height, ANS-Me/N-Me increased, vertical ratio Anterior lower facial height/ Posterior lower facial height decreased, and posterior/ anterior face height (S-Go/N-Me) increased, indicating growth of the lower face vertically and the outgrowth of

Table 1. Cephalometric Analysis of the ARS Group

		T0	T1	T1-T0	*P* Value
Maxilla to cranium	SNA(°)	80.60 ± 4.07	80.63 ± 4.10	0.03 ± 0.18	.437
Mandible to cranium	SNB(°)	72.95 ± 4.09	74.35 ± 4.03	1.40 ± 1.01	.00***
	Facial angle (FH-NPo)(°)	83.28 ± 3.21	84.34 ± 3.50	1.06 ± 1.54	.00***
	Convexity (NA-APo)(°)	15.69 ± 3.76	12.83 ± 4.70	−2.86 ± 2.38	.00***
	MP-FH(°)	33.24 ± 6.77	32.21 ± 6.23	−1.03 ± 1.88	.01**
	MP-SN(°)	39.89 ± 6.50	38.67 ± 6.10	−1.22 ± 1.20	.00***
	Co-Go(mm)	55.49 ± 3.53	57.90 ± 3.62	2.41 ± 3.07	.00***
	S Vert-Co(mm)	8.92 ± 3.66	7.70 ± 3.39	−1.22 ± 2.44	.02*
	SN/GoMe(%)	103.42 ± 7.32	105.12 ± 6.91	1.7 ± 4.57	.08
	y-axis (SGn-SN)(°)	76.57 ± 4.94	75.55 ± 4.65	−1.02 ± 1.11	.00***
Mandible to maxilla	ANB(°)	7.67 ± 1.42	6.27 ± 1.84	−1.40 ± 0.98	.00***
	Wits(mm)	5.50 ± 2.75	2.63 ± 3.01	−2.87 ± 2.23	.00***
Facial height	ANS-Me:N-Me(%)	54.30 ± 2.55	54.85 ± 2.40	0.55 ± 0.61	.00***
	Vertical ratio (Anterior lower facial height/Posterior lower facial height)	1.55 ± 0.15	1.50 ± 0.13	−0.05 ± 0.06	.00***
	Posterior-anterior face height (S-Go/N-Me)(%)	62.26 ± 5.24	64.19 ± 4.24	1.93 ± 2.82	.00***
Dentoalveolar	Overjet(mm)	6.92 ± 2.44	3.99 ± 1.54	−2.93 ± 2.00	.00***
	Overbite(mm)	0.40 ± 3.11	0.03 ± 2.55	−0.37 ± 2.07	.4
Soft tissue	Facial convexity(°)	18.38 ± 4.27	16.21 ± 5.34	−2.17 ± 2.96	.00***
	Soft tissue N Vert to Soft tissue pogonion(mm)	−4.83 ± 5.79	−2.68 ± 6.14	2.15 ± 3.00	.002**
	Sn to G vert(mm)	4.42 ± 2.84	4.60 ± 2.94	0.18 ± 1.39	.54
	Upper lip to Eline(mm)	1.76 ± 2.03	0.49 ± 2.22	−1.27 ± 0.87	.00***
	Lower lip to Eline(mm)	4.00 ± 2.55	4.06 ± 2.41	0.06 ± 1.32	.82

* $P < .05$ ** $P < .01$ *** $P < .001$.

the ramus compared with the anterior lower face (Table 1).

Among soft tissue measurements, ST N Vert to ST pogonion increased by 2.15 ± 3.00 mm ($P = .002$). Facial convexity and upper lip to Eline decreased ($P < .001$) (Table 1).

The SNA was 80.60 ± 4.07 and 80.63 ± 4.09 at T0 and T1, respectively ($P = .437$). There was no significant change in SNA, SN/GoMe (which represented the length of the mandibular body), or Sn to G Vert (which represented the position of the subnasale point).

Table 2. Cephalometric Analysis of the SS Group

		T0	T1	T1-T0	*P* Value
Maxilla to cranium	SNA(°)	81.17 ± 3.20	81.17 ± 3.30	0.00 ± 0.26	1.00
Mandible to cranium	SNB(°)	71.60 ± 4.14	70.70 ± 4.21	−0.90 ± 0.93	.00**
	Facial angle (FH-NPo)(°)	80.53 ± 4.21	79.73 ± 4.28	−0.8 ± 1.34	.01**
	Convexity (NA-APo)(°)	20.00 ± 6.37	21.54 ± 6.71	1.54 ± 2.03	.00**
	MP-FH(°)	38.53 ± 6.05	39.07 ± 7.01	0.54 ± 1.60	.12
	MP-SN(°)	44.16 ± 6.80	44.82 ± 7.29	0.66 ± 2.14	.16
	Co-Go (mm)	55.87 ± 6.14	55.40 ± 6.08	−0.47 ± 2.73	.42
	S Vert-Co (mm)	7.81 ± 3.44	7.40 ± 2.79	−0.41 ± 2.37	.42
	SN/GoMe	110.21 ± 12.05	110.10 ± 11.66	−0.11 ± 4.41	.90
	y-axis (SGn-SN)(°)	78.51 ± 4.10	79.47 ± 4.38	0.96 ± 1.00	.00**
Mandible to maxilla	ANB(°)	9.57 ± 2.78	10.47 ± 3.01	0.91 ± 0.97	.00**
	Wits(mm)	5.98 ± 3.93	7.47 ± 4.21	1.49 ± 1.60	.00**
Facial height	ANS-Me:N-Me(%)	54.43 ± 2.63	54.27 ± 2.60	−0.16 ± 0.70	.28
	Vertical ratio Anterior lower facial height/Posterior lower facial height	1.63 ± 0.13	1.62 ± 0.13	−0.01 ± 0.07	.38
	Posterior-anterior face height (S-Go/N-Me)	59.37 ± 4.21	58.92 ± 4.49	−0.45 ± 1.73	.23
Dentoalveolar	Overjet(mm)	5.51 ± 2.04	7.23 ± 2.42	1.72 ± 1.72	.00**
	Overbite(mm)	1.33 ± 2.49	0.28 ± 2.29	−1.05 ± 1.69	.01**
Soft tissue	Facial convexity(°)	21.42 ± 6.21	23.07 ± 6.54	1.65 ± 2.67	.01**
	Soft tissue N Vert to Soft tissue pogonion(mm)	−8.70 ± 7.27	−10.43 ± 7.65	−1.74 ± 3.66	.033*
	Sn to G Vert(mm)	3.56 ± 2.72	3.66 ± 2.55	0.1 ± 1.55	.76
	Upper lip to Eline(mm)	2.12 ± 2.02	2.70 ± 2.43	0.58 ± 1.44	.07
	Lower lip to Eline(mm)	5.46 ± 2.53	5.52 ± 2.61	0.06 ± 1.30	.84

* $P < .05$ ** $P < .01$.

Table 3. Sex and Age Between Groups

	ARS (n = 24)	SS (n = 23)	*t*	*P*
Sex	1.04 ± 0.20	1.13 ± 0.34	−1.069	.292
Age, y	20.38 ± 3.27	23.70 ± 4.07	−3.09	.003**

** $P < .01$.

In group SS, 18 of 23 patients (78.3%) showed a backward shift tendency after SS therapy. The SNB angle was initially 71.60 ± 4.14° and was reduced to 70.70 ± 4.21° at T1 by an average of 0.90 ± 0.93° ($P < .001$). The ANB angle increased by 0.91 ± 0.97°, from 9.60 ± 2.78° at T0 to 10.47 ± 3.01° at T1 ($P < .001$). Overjet increased by 1.72 ± 1.72 mm ($P < .001$). Wits increased by 1.49 ± 1.60 mm ($P < .001$). The facial angle (FH-NPo) decreased ($P = .01$), convexity (NA-APo) increased ($P < .001$), and y-axis (SGn-SN) increased, implying mandibular retrusion. Overbite decreased by 1.05 ± 1.69 mm ($P = .01$) (Table 2).

ST N Vert to ST pogonion decreased by 1.74 ± 3.66 mm ($P = .033$). Facial convexity also increased ($P = .01$) (Table 2).

The SNA was 81.17 ± 3.20° at T0 and 81.17 ± 3.30° at T1 (Table 2); this change was not significant. The changes in MP-FH, MP-SN, Co-Go, Sn, and G Vert were also nonsignificant (Table 2).

MRIs showed that the condylar height increased by 1.45 ± 3.05 mm ($P = .002$) in group ARS. In group SS, the condylar height change was not significant (Table 4).

DISCUSSION

Occlusal SSs and ARSs are widely used, conservative methods in clinical practice for TMD patients. Their roles in attenuating mechanical stresses on the TMJ, eliminating symptoms including pain and sound, and improving mandibular functional movement have been well documented.[14]

The effects of SSs include decrement of the mechanical load on the TMJ, stabilization of the occlusion, and relaxation of masticatory muscles. SS is effective in restoring normal masticatory muscle function and bite position, possibly by eliminating the discrepancy between centric relation and intercuspation commonly observed in TMD patients.[15] When applied to idiopathic condylar resorption patients, SS could prevent further bone destruction and promote condylar remodeling compared with the control group.[16] Patients with temporomandibular joint osteoarthritis receiving SS therapy exhibited bone formation in the anterior division of the condyle, whereas the non-SS group showed mostly no change.[17] SS stabilizes the condylar position, revealing the true mandible position. In orthodontic clinical practice, the usual treatment procedure for DJD patients, especially for those in the progressive stage, involves SS therapy before orthodontics.[18,19] However, most past studies were case reports.

The current study indicated that the average SNB increase was 0.90 ± 0.93°. The mandible moved backward as shown in a typical case in Figure 2A-C. This could provide a reference for predicting prognosis to orthodontists before actual treatment. For skeletal Class II DJD patients, discreet doctor-patient communication about the underlying severity of the skeletal deformity should proceed, and a comprehensive treatment plan with orthodontics and orthognathic surgery might be taken into consideration.

ARS is another common splint with emerging evidence of its advantages of condylar bone repair and regeneration along with disc-condyle relationship correction. For adolescents and young adults with TMJ disc displacement with reduction (DDwR), "disc-recapture" rates with ARS and SS were 96.7% and 33.3%, respectively.[20] Among patients with acute TMJ disc displacement without reduction, combined therapy of arthrocentesis, mandibular manipulation, and ARS succeeded in 95.2% of patients.[21] For degenerative TMD patients, ARS was also found to promote condylar repair and regeneration, which was significantly higher (78.1%) than that in the control group (48.6%).[22] On the other hand, long-term stability appeared to be less favorable. At 6 months after ARS treatment, only 40.6% of the joints were maintained in the normal disc-condyle relationship.[23] Other studies confirmed that the long-term effectiveness of ARS in recapturing DDwR was only 53%–72.53%.[24,25] Younger age, female sex, longer treatment duration,

Table 4. Condylar Height Between Groups

	Condylar Height							
	T0		T1		T1-T0			
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	*t*	*P* Value
ARS	22.43	3.42	23.88	3.91	1.45	3.91	−3.29	.002**
SS	25.13	5.49	24.87	5.50	−0.26	2.11	0.83	.412

** $P < .01$.

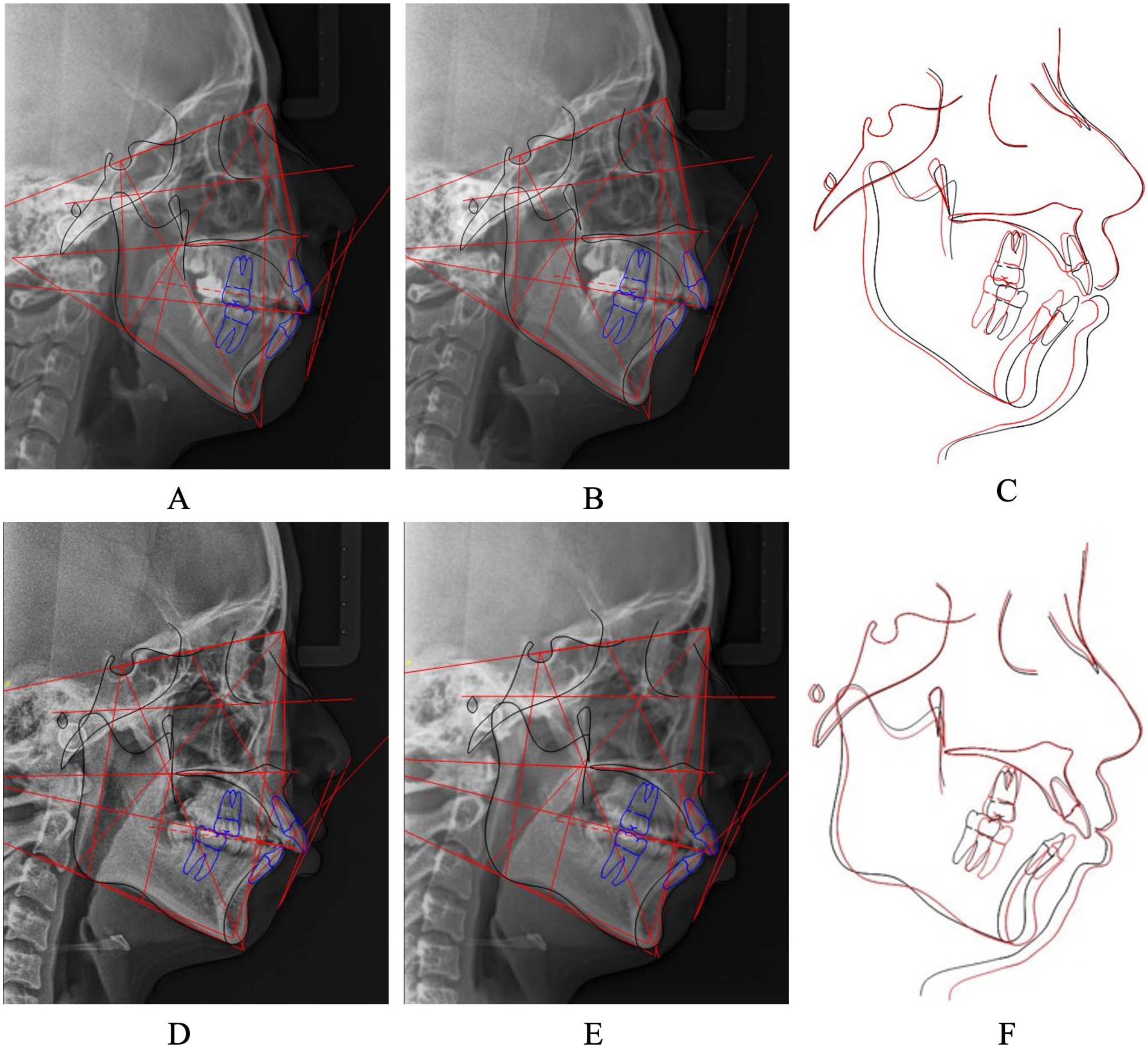

Figure 2. Cephalometric superimposition: (A) SS T0, (B) SS T1, (C) SS superimposition, (D) ARS T0, (E) ARS T1, and (F) ARS superimposition.

and posttreatment orthodontic treatment seemed to be correlated with better treatment stability.

Nearly half of the recurrence rate of the disc-condyle relationship after ARS treatment in the long-term is barely satisfactory. Some doctors advocate for disk repositioning surgery or combined therapy of disk repositioning surgery and ARS. Better long-term stability of the disc-condyle relationship and new bone formation on the surface of the condyle were found in disk repositioning surgery patients with or without ARS.[26–28] However, the percentage of new bone formation after disk repositioning without ARS was decreased in older patients.[29]

The current study confirmed the effect of condylar regeneration and mandibular growth after disk repositioning and ARS in young adults. The SNB angle increased and the ANB angle decreased. In addition, vertical measurements, including MP-FH, MP-SN, and y-axis, all decreased, suggesting counterclockwise rotation of the mandible. The increase in ANS-Me:N-Me indicated vertical growth of the lower face. However, the decrease in the vertical ratio Anterior lower facial height/Posterior lower facial height and the increase in the posterior/anterior facial height (S-Go/N-Me) ratio indicated the outgrowth of the posterior part of the lower face. Therefore, the severity of skeletal

Class II and the hyperdivergent growth pattern were alleviated. A typical case is shown in Figure 2D-F. This treatment approach also improved the Class II profile and sustained camouflage orthodontic treatment afterward. For borderline cases, orthognathic surgery might be avoided.

TMD is a complex multidisciplinary disease lacking standard treatment guidelines. Various treatment approaches are often based on doctor training experience. The consensus is that invasive treatment should be based on discreet evaluation including the stages of TMD, the life quality influenced by the condition, the severity of craniofacial morphology discrepancy, and the patient's willingness to undergo surgery.

CONCLUSIONS

- TMJ disc surgery followed by postoperative ARS could promote condylar bone remodeling and regeneration. The patients' SNB angle increased, the ANB angle decreased, and the ratio of posterior lower facial height increased. Therefore, the severity of skeletal Class II and the hyperdivergent growth pattern were alleviated, which sustained camouflage orthodontic treatment instead of orthognathic surgery for borderline cases.
- The SS, on the other hand, enabled the mandible to withdraw backward. The patients' SNB angle decreased, and the ANB angle increased markedly. After SS therapy, a much more retrognathic, but true, mandible position is revealed. According to this position, the subsequent combined treatment of orthodontics and orthognathic surgery should be considered.
- In this study, two different effective treatment approaches for skeletal Class II DJD were offered. ARS and SS exhibited different influences on mandible position and condylar remodeling.

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