# EFFECT OF ORTHODONTIC-STRAIGHT JAW COMBINED THERAPY OF SKELETAL ANGLE CLASS III MALOCCLUSION ON TEMPOROMANDIBULAR JOINT MORPHOLOGY AND MANDIBULAR MOVEMENT FUNCTION

Xin Li[#], Jieyun Zhang[#], Shishu Fang, Zuolin Jin[*]
State Key Laboratory of Military Stomatology and National Clinical Research Center for Oral Diseases and Shaanxi Clinical Research Center for Oral Diseases, Department of Orthodontics, School of Stomatology, the Fourth Military Medical University, Xi'an, 710032, Shanxi Province, China
[#]*The first two authors contributed equally to this article*

***ABSTRACT***

***Objective:*** *To study the effect of orthodontic-straight jaw combined therapy of skeletal Angle class III malocclusion on temporomandibular joint (TMJ) morphology and mandibular movement function.*

***Methods:*** *38 patients with skeletal Angle class III malocclusion admitted to our hospital from January 2019 to December 2020 were selected as the research object and given the orthodontic treatment combined with bilateral sagittal split ramus osteotomy (BSSRO) for straight jaw to compare their indexes of TMJ morphology and mandibular movement function before and after treatment.*

***Results:*** *One month after surgery, various joint space indexes were significantly different compared with those before surgery; except for the left S1, there were statistical differences among the remaining indexes after correction when comparing with those at postsurgical one month, but no obvious difference was obtained if comparing with those before surgery; at 1 month after surgery, patients' right P01 and P02 were significantly different from those before surgery, but were recovered to the presurgical status after correction; the left P02 at postsurgical 1 month was significantly higher than that before surgery and after correction; 5 of 11 patients with clicking of joint and 5 of 6 patients with abnormal mouth opening were healed, with statistically significant differences before and after treatment; in addition, no obvious change was seen in Angle I, Angle II and Height.*

***Conclusion:*** *Applying the orthodontic-straight jaw combined therapy in the treatment of skeletal Angle class III malocclusion does not cause change in the glenoid fossa morphology or TMJ disorder related diseases, also, as some patients with abnormal mouth opening and clicking of joint were healed after treatment, it has certain efficacy to treat TMJ disorders.*

***Keywords:*** *Mandibular movement function, temporomandibular joint morphology, skeletal Angle class III malocclusion, orthodontic-straight jaw.*

*DOI: 10.19193/0393-6384_2021_5_424*

***Received*** *March 15, 2021;* ***Accepted*** *June 20, 2021*

## Introduction

Skeletal Angle class III malocclusion is a common deformity in the clinic that has serious adverse effect on patients' facial appearance, language function and occlusal function, and even causes disorders of the internal mandibular joint in severe causes[1-4]. Currently, mild Angle class III malocclusion is usually treated with orthodontic therapy alone in the clinic with better results, but for patients with severe condition, to achieve a fine outcome while realizing facial aesthetics and stable occlusal function, the orthodontic-straight jaw combined therapy should be adopted. Bilateral sagittal split ramus osteotomy (BSSRO) combined with the orthodontic treatment before and after surgery is a common scheme for treating skeletal Angle class III malocclusion in the clinic[5-8]. The

rigid internal fixation technique used in BSSRO surgery is conductive to bone tissue healing, guaranteeing a desirable outcome. However, further research on postoperative stability and complication prevention and cure is still required in the medical field. Theoretically speaking, BSSRO should have positive effect on TMJ for it corrects the abnormal jaw, but cases with TMJ disorder were found in patients after BSSRO in the clinic.

Based on this, 38 patients with skeletal Angle class III malocclusion admitted to our hospital were selected as the research object to deeply explore the effect of orthodontic-straight jaw combined therapy of skeletal Angle class III malocclusion on TMJ morphology and mandibular movement function.

## Materials and methods

### *General information*

38 patients with skeletal Angle class III malocclusion admitted to our hospital from January 2019 to December 2020 were selected as the research object, with the male-female ratio being 22:16, initial age for treatment being 19-28 years old, and the mean age being (22.4±1.5) years old.

*Inclusion criteria:*

• Patients had skeletal Angle class III malocclusion (∠ANB<-5°, ∠IMPA<85°) with incisor compensation;

• Patients were over 18 years old with complete craniofacial growth and development;

• Patients' medical records were complete;

• The study was approved by the Hospital Ethics Committee, and patients and their family members signed the informed consent after fully understanding the research objective and process.

*Exclusion criteria for patients:*

• Trauma induced malformation and cleft lip and palate deformity;

• craniofacial congenital genetic syndrome;

• History of maxillofacial surgery;

• Presence of cognitive dysfunction, motor dysfunction or communication dysfunction.

### *Methods*

*Presurgical orthodontic:*

• Based on factors including patients' dentition crowding degree, compensation degree, degree of incoordinate dental arch, nasolabial angle of soft tissues, and depth of Spee's curve, the appropriate tooth extraction mode was selected to relieve the crowded dentition and align the upper and lower teeth so that the ideal occlusal curve could be recovered[9-12];

• The dental compensation was removed. Normally, maxillary extraction would be adopted for more obvious compensation of premaxillary teeth labial tipping, while non-extraction mode was suitable for those with less obvious upper dentition problem or slight compensation of premaxillary teeth labial tipping;

• The shape and arch width of the upper and lower teeth were coordinated;

• For orthodontic treatment, the stage model was observed periodically to analyze the occlusivity of jaw retention at the rearmost of dentition and clear occlusal interference, preventing postsurgical relapse.

*Orthodontic surgery*

Based on the degree of deformity in patients, the unimandibular surgery (BSSRO for lower jaw) or the bimaxillary surgery (BSSRO for lower jaw plus Le Fort I osteotomy for upper jaw) was determined. During the surgery, accurate wearing of splint was required to implement the internal fixation of bone segment by the IRF technique. Intermaxillary elastic traction was performed with planting nail in conjunction with hot compressing for swelling reducing and attention on diet after surgery[13-14].

*Postsurgical orthodontics and maintenance*

The fixation period of rigid internal fixation surgery usually lasted for 2-3 weeks, so orthodontic treatment was possible around the 4th postsurgical week to mainly stabilize the re-established positional relation of jaw, close the remaining spaces, and finely adjust the occlusion[15-17] with the following specific steps.

• The loose brackets were trimmed and the dentition was adjusted with high-elastic arch wire. Usually the maxillary incisor torque was controlled with a square arch wire, and the thinner NiTi round arch wire was selected for the first wire in postoperative orthodontics of lower jaw;

• The remaining spaces were closed with the sliding mechanism after replacing with the stainless steel square wire;

• Upon replacement, the sagittal relation between the upper and lower jaws was adjusted by auxiliary short class III traction to stabilize the new jaw relation and prevent tooth disarray;

• Triangular traction could also be used to finely adjust the occlusal relation, and the vertical elastics in anterior teeth area was used to correct and maintain proper occlusal coverage relation;

• The time for patients to stop intermaxillary traction after stable occlusion could be appropriately increased to prevent recurrence; in addition, occlusal interference and poor contact of adjacent teeth were observed and adjusted timely during orthodontic treatment.

X-ray film and measurement. Patients' anteroposterior and lateral skull X-ray films, intercuspal position (ICP), standard Schüller's projection of the largest mouth opening, and panoramic tomography were taken before and after treatment with the same equipment. The joint spaces and glenoid fossa morphology were measured according to the Cohlmia method (see Figure 1).

The superior border of the joint X-ray film negative was the baseline L1, which was paralleled to L2, L3 and L4; L2 was tangential to the superior border of glenoid fossa at SF, L3 was tangential to the superior border of condyle at SC, and L4 was tangential to the top of articular eminence at AE; passing through SF, one line was tangent to the anterior border of condyle at AC, and the other was tangent to the posterior border of condyle at PC; the line passing through AC and vertical to the tangent of the anterior border of condyle was tangential to the anterior border of glenoid fossa at AF, and the line passing through PC and vertical to the tangent of the posterior border of condyle was tangential to the posterior border of glenoid fossa at PF; and L5 and L6 were the tangents to the anterior oblique plane and posterior oblique plane of glenoid fossa, respectively.

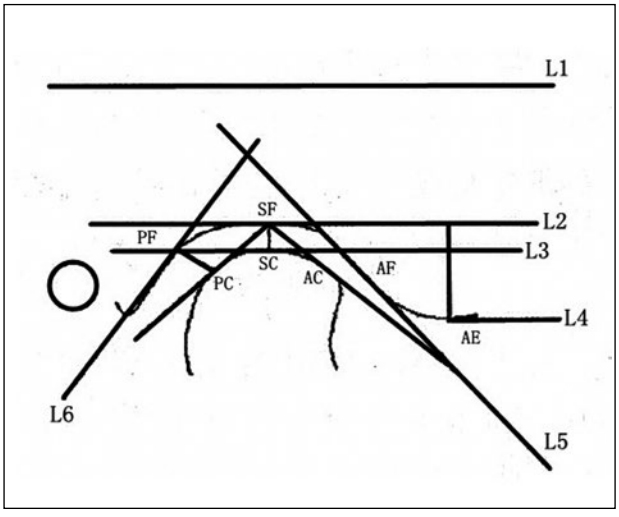


**Figure 1:** Schematic diagram of Cohlmia method.

***Observation indexes***

• Posterior joint space (P1), the distance from PF to PC.

• Superior joint space (A1), the distance from AF to AC.

• Upper joint space (S1), the distance from SF to SC.

• Height of articular eminence (Height), the vertical distance from AE to L2.

• Angle 1, the angle between L1 and L5.

• Angle 2, the angle between L6 and L5.

• P01=P1/A1, indicated the sagittal position of condyle.

• P02=S1/Height, indicated the vertical position of condyle.

• Angle 1, Angle 2 and Height, indicated the glenoid fossa morphology.

***Statistical processing***

In this study, the data processing software was SPSS20.0, the picture drawing software for data was GraphPad Prism 7 (GraphPad Software, San Diego, USA), items included were enumeration data and measurement data, methods used were $X^2$ test, t-test, and normality test, and differences were considered statistically significant at $P<0.05$.

## Results

***Comparison of joint spaces before and after treatment***

One month after surgery, various indexes of patients were significantly different from those before surgery ($P<0.05$); except for the left S1, there were statistical differences among the remaining indexes after correction when comparing with those at one month after surgery, but no obvious difference was obtained when comparing with those before surgery ($P>0.05$), see Table 1.

| | Before surgery | 1 month after surgery | After correction |
|---|---|---|---|
| Right | | | |
| P1 (mm) | 2.98±0.73 | 3.66±1.23* | 3.05±0.91** |
| A1 (mm) | 2.01±0.76 | 2.64±0.85* | 2.03±0.74** |
| S1 (mm) | 2.67±1.05 | 3.72±0.51* | 2.59±0.68** |
| Left | | | |
| P1 (mm) | 2.91±1.18 | 3.62±1.23* | 2.88±0.82** |
| A1 (mm) | 1.97±0.68 | 2.89±0.54* | 2.11±0.75** |
| S1 (mm) | 2.88±0.62 | 3.56±0.83* | 2.69±0.67 |

**Table 1:** Comparison of joint spaces before and after treatment (n=38, $\bar{x}\pm s$).

**indicated P<0.05 versus before surgery; and **indicated P<0.05 versus one month after surgery.*

***Right condyle position and glenoid fossa morphology***

At 1 month after surgery, patients' right P01 and P02 were significantly different from those before surgery (P<0.05), but after correction, they returned to the presurgical status (P>0.05); and the differences in Angle 1, Angle 2 and Height were not significant before and after treatment (see Figure 2 and Table 2).

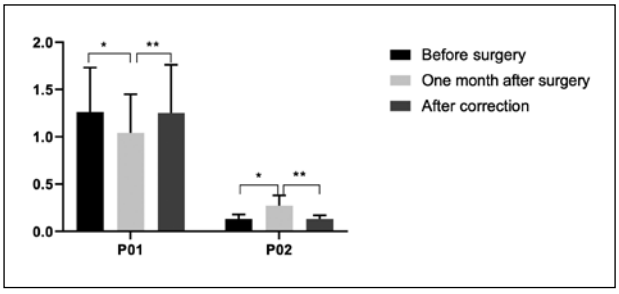


**Figure 2:** Comparison of right P01 and P02 (n=38, $\bar{x}\pm s$). *Note: The horizontal axis indicated P01 and P01, and the vertical axis indicated the values. Patients' P01 and P02 before surgery were (1.26±0.47) and (0.13±0.05), respectively; Patients' P01 and P02 at 1 month after surgery were (1.04±0.41) and (0.27±0.11), respectively; Patients' P01 and P02 after correction were (1.25±0.49) and (0.13±0.04), respectively; *from left to right indicated that P01 and P02 before surgery were significantly different from those at 1 month after surgery (t=2.1744, 7.1424, P=0.0329, 0.000); and **from left to right indicated that P01 and P02 at 1 month after surgery were significantly different from those after correction (t=2.0262, 7.3733, P=0.0464, 0.000).*

| Time point | Angle1 (°) | Angle 2 (°) | Height (mm) |
|---|---|---|---|
| Before surgery | 124.29±8.45 | 78.61±10.59 | 8.37±1.58 |
| 1 month after surgery | 126.73±7.95 | 80.17±9.88 | 8.45±1.67 |
| After correction | 126.12±8.26 | 79.54±10.13 | 8.39±1.55 |

**Table 2:** Comparison of Angle 1, Angle 2 and Height (n=38, $\bar{x}\pm s$).

***Left condyle position and glenoid fossa morphology***

No obvious change was seen in the left P01, Angle 1, Angle 2 and Height during the treatment; and P02 at 1 month after surgery was significantly higher than that before surgery and after correction, with statistical differences (see Figure 3 and Table 3).

***Comparison of TMJ function***

Five of eleven patients with clicking of joint and five of six patients with abnormal mouth opening were healed, with statistical differences before and after treatment (P<0.05), see Table 4.

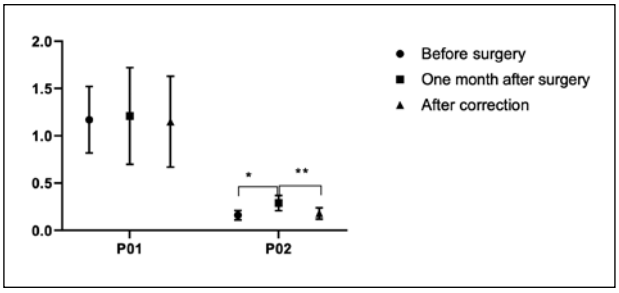


**Figure 3:** Comparison of left P01 and P02 (n=38, $\bar{x}\pm s$). *Note: The horizontal axis indicated P01 and P02, and the vertical axis indicated the values. Patients' P01 and P02 before surgery were (1.17±0.35) and (0.16±0.05), respectively; Patients' P01 and P02 at 1 month after surgery were (1.12±0.51) and (0.29±0.08), respectively; Patients' P01 and P02 after correction were (1.15±0.48) and (0.18±0.06), respectively; *indicated that P02 before surgery was significantly different from that at 1 month after surgery (t=8.4945, P=0.000); and **indicated that P02 at 1 month after surgery was significantly different from that after correction (t=6.7809, P=0.000).*

| Time point | Angle1 (°) | Angle 2 (°) | Height (mm) |
|---|---|---|---|
| Before surgery | 123.52±7.54 | 75.59±10.01 | 8.33±1.82 |
| 1 month after surgery | 125.43±8.17 | 73.49±9.75 | 8.46±1.91 |
| After correction | 123.69±7.63 | 74.76±12.89 | 8.41±0.78 |

**Table 3:** Comparison of Angle 1, Angle 2 and Height (n=38, $\bar{x}\pm s$).

| | Clicking of joint | Abnormal mouth opening |
|---|---|---|
| Before treatment | 11 (28.95) | 6 (15.79) |
| After treatment | 4 (10.53) | 1 (2.63) |
| $X^2$ | 4.0699 | 3.9337 |
| P | 0.044 | 0.047 |

**Table 4:** Comparison of TMJ function [n(%)].

## Discussion

The effect of orthodontic-straight jaw combined therapy, especially on the joint spaces, has always been a focus in the clinic and a key study point of many scholars[18-21]. Ieva gavar[22] et al. previously used CT scan and 3D finite element method to conclude that the therapy could change the spatial position of mandible, and at the same time the stress environment of each structure within joint spaces was changed accordingly, which was beneficial to the recovery of joint function. With BSSRO surgery for skeletal Angle class III malocclusion, the width between mandibular ramuses would be decreased,

leading to the change in condyle position, but after a period of self-regulation, the condyle would return to its original position. The results also shown that one month after surgery, various joint space indexes were significantly different compared with those before surgery; except for the left S1, there were statistical differences among the remaining indexes after correction when comparing with those at postsurgical one month, but no obvious difference was obtained if comparing with those before surgery, indicating that joint spaces were enlarged obviously and the condyle moved backward but self-adjusted to normal after correction, which was related to the changes in the occluding relation and the relation between maxilla and mandible; in addition, TMJ space was basically recovered after correction due to the stress change in the internal structure of TMJ, stimulating the absorption of condyle and TMJ remodeling and realizing new tissue balance. The literature of Ishida[23] et al. mentioned that although the condyle position was changed after performing BSSRO, the conclusion that condylar cartliage had the ability to adapt to a new stress environment was drawn according to the change in patients' bone mineral density.

The study also found that at 1 month after surgery, patients' right P01 and P02 were significantly different from those before surgery, but were recovered to the presurgical status after correction; the left P02 at postsurgical 1 month was significantly higher than that before surgery and after correction, indicating that the sagittal position of condyle moved backward and downward. In addition, no obvious change was seen in indexes that reflect the glenoid fossa morphology such as Angle 1, Angle 2 and Height. 5 of 11 patients with clicking of joint and 5 of 6 patients with abnormal mouth opening were healed, with statistically significant differences before and after treatment, presenting that the orthodontic-straight jaw combined therapy could reduce poor joint symptoms in patients with TMJ disorder. After three years of follow-up, Johannes Alexander Tamme[24] and other scholars found that the original joint symptoms of the patients decreased from 72.6% to 25.4%, and that the stable occlusion functional environment could alleviate TMJ disorder after orthognathic surgery. Besides, Emma McCrory[25] et al. also mentioned in their study that after orthognathic surgery, the proportion of patients with joint pain, snapping or other joint disorder symptoms was decreased from 38% to 26%, and that of patients with more than one symptoms was decreased from 16% to 5%, proving that the orthognathic surgery was beneficial to relieve TMJ disorder, which was consistent with the conclusion of this study.

In conclusion, applying the orthodontic-straight jaw combined therapy in the treatment of skeletal Angle class III malocclusion does not cause change in the glenoid fossa morphology or TMJ disorder related diseases, also, as some patients with abnormal mouth opening and clicking of joint were healed after treatment, it has certain efficacy to treat TMJ disorders.

## References


1) Zhou, Yang, Wang, Xiaoxia, Zhou, Yanheng, et al. Progressive changes in patients with skeletal Class III malocclusion treated by 2-jaw surgery with minimal and conventional presurgical orthodontics: A comparative study[J]. American Journal of Orthodontics and Dentofacial Orthopedics, 2016, 149(2): 244-252.
2) Ohba, Seigo, Kohara, Haruka, Koga, Takamitsu, et al.Soft tissue changes after a mandibular osteotomy for symmetric skeletal class III malocclusion[J]. Odontology, 2017,105(3): 375-381.
3) Miao Luchi, Giuliano Henrique, Conci, Ricardo Augusto, Silveira Tomazi, Flavio Henrique, et al. Assessment of the Postoperative Stability of Mandibular Orthognathic Surgery for Correction of Class III Skeletal Malocclusion[J]. The Journal of craniofacial surgery, 2017, 28(1): 151-156.
4) Maria Fernanda Rabelo Bozzini,José Valladares-Neto, João Batista de Paiva, et al. Sex differences in pharyngeal airway morphology in adults with skeletal Class III malocclusion[J]. CRANIO®, 2018, 36(2): 98-105.
5) Tseng, Linda L. Y., Linda L Y Tseng, Chang, Chris H., et al. Diagnosis and conservative treatment of skeletal Class III malocclusion with anterior crossbite and asymmetric maxillary crowding[J]. American Journal of Orthodontics and Dentofacial Orthopedics, 2016, 149(4): 555-566.
6) Park, Jae Hyun, Yu, Joseph, Bullenc, Ryan.Camouflage treatment of skeletal Class III malocclusion with conventional orthodontic therapy[J].American Journal of Orthodontics and Dentofacial Orthopedics, 2017, 151(4): 804-811.
7) Wu Zuping, Zhang Xin, Li Zixuan, et al. A Bayesian network meta-analysis of orthopaedic treatment in Class III malocclusion: Maxillary protraction with skeletal anchorage or a rapid maxillary expander[J]. Orthodontics & craniofacial research, 2020, 23(1):1-15.
8) Alessandro Ugolini, Andrea Mapelli, Marzia Segù, et al.Three-dimensional mandibular motion in skeletal Class III patients[J]. CRANIO®, 2018, 36(2): 113-120.

9) Robert S D Smyth,Fiona S Ryan.Early treatment of class III malocclusion with facemask.[J].Evidence-based dentistry, 2017, 18(4): 107-108.
10) Zhang, Yixin, Guo, Runzhi, Fu, Zhen, et al. Dentoskeletal effects of facemask therapy in skeletal Class III cleft patients with or without bone graft[J].American Journal of Orthodontics and Dentofacial Orthopedics, 2018, 153(4): 542-549.
11) Gallone, Mariano, Robiony, Massimo, Bordonali, Daniele, et al. Multidisciplinary treatment with a customized lingual appliance for an adult patient with severe Class III malocclusion and multiple missing teeth[J]. American Journal of Orthodontics and Dentofacial Orthopedics, 2019, 156(3): 401-411.
12) Romero, L. Gaitan, Mulier, D., Orhan, K., et al. Evaluation of long-term hard tissue remodelling after skeletal class III orthognathic surgery: a systematic review[J]. International journal of oral and maxillofacial surgery, 2020, 49(1): 51-61.
13) SEUNG-MIN LIMS. Surgical-Orthodontic Correction of Skeletal Class III Malocclusion with Vertical Maxillary Excess[J]. Journal of clinical orthodontics: JCO, 2016, 50(12): 754-766.
14) Choi, Yoon Jeong, Chang, Jeong Eun, Chung, Chooryung J., et al.Prediction of long-term success of orthopedic treatment in skeletal Class III malocclusions[J]. American Journal of Orthodontics and Dentofacial Orthopedics, 2017, 152(2): 193-203.
15) Moon, Won. Class III treatment by combining facemask (FM) and maxillary skeletal expander (MSE)[J]. Seminars in orthodontics, 2018, 24(1): 95-107.
16) Woon, See Choong, Thiruvenkatachari, Badri. Early orthodontic treatment for Class III malocclusion: A systematic review and meta-analysis[J].American Journal of Orthodontics and Dentofacial Orthopedics, 2017, 151(1): 28-52.
17) Park, Jeong-Ho, Hong, Ji-Yeon, Ahn, Hyo-Won, et al. Correlation between periodontal soft tissue and hard tissue surrounding incisors in skeletal Class III patients[J]. Angle Orthodontist, 2018, 88(1): 91-99.
18) Li, Juan, Shen, Jiawei, Xu, Ji, et al. The Treatment Strategy of Cleidocranial Dysplasia: Combined Orthodontic and Orthognathic Treatment[J].The Journal of craniofacial surgery, 2019, 30(6): 1767-1771.
19) Gregory S. Antonarakis, Nicole Kalberer, Delphine S. Courvoisier, et al. Clinical predictive factors for temporomandibular disorders following combined orthodontic and orthognathic surgical treatment in patients with Class III malocclusion[J].CRANIO®, 2017, 35(6): 397-404.
20) Samantha J. Hodges, Nigel P. Hunt, Fawaz L Almutairi. Occlusal outcomes in combined orthodontic and orthognathic treatment[J]. Journal of orthodontics, 2017, 44(1): 28-33.
21) Dehghani, Mahboobe, Fazeli, Faryal, Sattarzadeh, Ali Payam.Efficiency and Duration of Orthodontic/Orthognathic Surgery Treatment[J]. The Journal of craniofacial surgery, 2017, 28(8): 1997-2000.
22) Ieva Gavare, Ilga Urtane, Gundega Jakobsone, et al. Apical Resorption of Upper Incisors and Canines During Orthodontic Treatment in Class III Orthognathic Surgery Patients – a Longitudinal Cone Beam Computer Tomography Study[J]. Acta Chirurgica Latviensis, 2018, 17(1): 23-28.
23) Ishida, Takayoshi, Manabe, Asuka, Yang, Shin-Sheng, et al. An orthodontic-orthognathic patient with obstructive sleep apnea treated with Le Fort I osteotomy advancement and alar cinch suture combined with a muco-musculo-periosteal V-Y closure to minimize nose deformity[J]. Angle Orthodontist, 2019, 89(6): 946-952.
24) Johannes Alexander Tamme, Michael Rohnen, Volker Ga?ling, et al. Correlation of general and oral health-related quality of life in malocclusion patients treated with a combined orthodontic and maxillofacial surgical approach[J]. Journal of Cranio-Maxillofacial Surgery, 2017, 45(12): 1971-1979.
25) Emma McCrory, Niall JP McGuinness, Aman Ulhaq. Reproducibility of the index of orthognathic functional treatment need scores derived from plaster study casts and their three-dimensional digital equivalents: a pilot study[J]. Journal of Orthodontics, 2018, 45(2): 94-101.

*Corresponding Author:*
Zuolin Jin
Department of Orthodontics, School of Stomatology, the Fourth Military Medical University, No 169 West Chang'le Road, Xi'an, 710032, Shanxi Province, China
Email: jinzuolin1031@126.com
*(China)*