Surgical Orthodontic Treatment Involving Mandibular Premolar Extraction in Patient with Mandibular Retrusion Associated with Temporomandibular Joint Osteoarthritis

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Abstract

Here, we report retention following surgical orthodontic treatment in a patient with vertical maxillary excess associated with temporomandibular joint osteoarthritis (TMJOA) and marked mandibular retrusion. The patient was a man aged 20 years 10 months who presented with the chief complaint of maxillary protrusion. The facial profile was of the convex type due to marked mandibular retrusion. In addition, the patient had a gummy smile. Intraoral findings revealed a Class II molar relation, +11 mm overjet, and 0 mm overbite. Mandibular dentition arch length discrepancy showed crowding of –2 mm, and the maxillary dentition showed a spaced arch of +5 mm. Panoramic radiographs confirmed flattening of the condylar head and proliferation of the bone margin. Cephalometric analysis of the skeletal pattern revealed that, horizontally, the maxilla was anterior and the mandible posterior; vertically, a dolichofacial pattern was noted. The anterior maxillary tooth axis was standard, but the anterior mandibular tooth axis showed labial inclination. Based on these findings, skeletal maxillary protrusion associated with TMJOA was diagnosed. Surgical orthodontic treatment comprised bilateral mandibular first premolar extraction with two-jaw surgery and genioplasty. Orthodontic treatment was performed with a multibracket system using a 0.022-slot pre-adjusted edgewise appliance. At 2 years and 11 months after initiation of treatment, the maxilla was transposed 6 mm upwards by orthognathic surgery and the mandible 17 mm anteriorly and 5 mm upwards by counterclockwise rotation. At 3 years and 10 months, the Pogonion was moved 6 mm

anteriorly by genioplasty. At 4 years, orthodontic treatment was concluded on confirming satisfactory occlusion and improvement in facial features. At 2 years after completion of treatment, occlusion and the maxillofacial morphology remain stable, with almost no relapse. In addition, no temporomandibular joint disorder symptoms have occurred. Careful comprehensive follow-up observation will be continued.

Key words: Osteoarthritis — Maxillary protrusion — Mandibular retrusion — Surgical orthodontic treatment — Class III molar relation

Introduction

Absorption and deformation of the condylar head due to temporomandibular joint osteoarthritis (TMJOA) have been reported to induce secondary change in maxillofacial morphology and occlusion. This included opening of the mandibular plane, an increase in the height of the lower half of the face, and retraction of muscle, partly due to deficiency in the mandibular ramus^{4,12)}. Elongation and labial inclination of the maxillary anterior teeth together with lingual inclination of the mandibular anterior teeth due to dental compensation are observed in many such cases. Such deformation accompanying clockwise rotation of the maxilla and the mandible is difficult to improve by orthodontic treatment alone. In this situation, the goal will ideally be to improve the anterior maxillary and mandibular tooth axes by means of pre-surgical orthodontic treatment and improve occlusion and facial appearance by orthognathic surgery aimed at moving the maxilla upward and advancing the mandible counterclockwise. In addition, such a treatment plan has been reported to be advantageous in terms of expansion of the upper airway¹⁹⁾.

Advancing the mandible, however, also increases the risk of relapse. Moreover, recent studies have focused on progressive condylar resorption (PCR)⁹⁾, particularly in patients who have undergone pre-surgical treatment for TMJOA. This is because the risk of PCR may be further increased and improvement of facial features insufficient due to post-surgical occlusal stability in the aforementioned

surgical plan.

Here, we report a case of retention following surgical orthodontic treatment (two-jaw surgery and genioplasty) after extraction of the mandibular first premolar in a patient with vertical maxillary excess associated with TMJOA and marked mandibular retrusion.

Case Presentation

Written informed consent was obtained from the patient for inclusion in this case report. The patient was a man aged 20 years 10 months in whom malocclusion had been diagnosed by a general dentist when he was in junior high school. He presented at our hospital with the chief complaint of maxillary protrusion. His family history revealed that his mother and younger sister had maxillary protrusion. The patient had a past medical history of allergic rhinitis. When he was in high school, TMJ disorder was noted due to clicking and joint pain, but the condition was left untreated. On presenting at our department, no symptoms of TMJ disorder were noted. Moreover, the patient had no past history of rheumatoid arthritis.

Although the frontal facial view was almost symmetrical, marked mandibular retrusion resulted in the profile being of a convex type. With respect to the E-line, the upper and lower lips protruded by +14 mm and +17 mm, respectively. In addition, the patient had a gummy smile, incomplete lip closure, and marked tension in the mentalis muscle (Fig. 1). Intraoral findings revealed a Class II

Fig. 1 Pre-treatment facial photographs at age 20y10m

Fig. 2 Pre-treatment intraoral photographs at age 20y10m

Fig. 3 Pre-treatment panoramic radiograph at age 20y10m

molar relation, +11 mm overjet, and 0 mm overbite. Mandibular dentition arch length discrepancy showed -2 mm crowding, while

the maxillary dentition showed a +5.0 mm spaced arch. In addition, incomplete eruption of the mandibular second molar due to insufficient space in the posterior mandible was noted (Fig. 2). Panoramic radiographs revealed deformity of both condyles, together with erosion and flattening of both components. Osteophytes were present on both condyle heads. The right joint space was narrowed. The third molars were all present, except for that in the left maxilla (Fig. 3). Oral respiration and tongue thrusting habit were noted as functional problems.

Cephalometric analysis revealed an SNA of 89°, SNB of 75°, anteroposterior convexity of 30°, a mandibular plane angle of 42°, Y-axis of

Measurement	Mean $\pm$ S.D.	Pre Treat.	Post Treat.	Post Ret.
Facial angle (deg.)	85.9 $\pm$ 1.69	82	91	90
Convexity (deg.)	5.5 $\pm$ 2.93	30	13	14
A-B plane (deg.)	-4.3 $\pm$ 1.81	-16	-12	-12.5
Mandibular plane (deg.)	26.4 $\pm$ 3.83	42	36	37
Y-axis (deg.)	64.3 $\pm$ 2.27	70	62	63
Occlusal plane (deg.)	8.6 $\pm$ 5.56	15.5	9	10
Interincisal angle (deg.)	121.9 $\pm$ 3.69	106	134	135
L-1 to Occlusal (deg.)	23.7 $\pm$ 5.30	37	20	19
L-1 to Mandibular (deg.)	98.2 $\pm$ 4.08	100	83	82
U-1 to A-P plane (mm)	9.2 $\pm$ 2.24	21	7	7.5
FH to SN plane (deg.)	5.8 $\pm$ 3.07	8.5	8.5	8.5
SNA (deg.)	83.2 $\pm$ 3.44	89	89	89.5
SNB (deg.)	80.4 $\pm$ 3.22	75	81	80.5
SNA-SNB diff. (deg.)	2.8 $\pm$ 5.98	14	8	9
U-1 to FH plane (deg.)	115.2 $\pm$ 5.86	112	107	106
L-1 to FH plane (deg.)	58.0 $\pm$ 5.98	38	61	61
Gonial angle (deg.)	120.2 $\pm$ 4.04	131	131	131
Ramus angle (deg.)	85.7 $\pm$ 4.55	91	85	86

Fig. 4 Tracing and measurements on pre-treatment cephalometric radiograph

70°, and a vertical gonial angle of 131°. Maxillary protrusion and marked mandibular retrusion were observed. A dolichofacial type was noted. Regarding the denture pattern, the maxillary anterior tooth axis was standard, with an U-1 to FH of 112°, but the mandibular anterior tooth axis had a labial inclination, with an L-1 to FH of 38° and L-1 to mandibular plane of 100° (Fig. 4).

Therefore, the list of concerns in this case included: (1) mandibular retrusion and a dolichofacial pattern; (2) vertical maxillary excess; (3) labial inclination of the mandibular anterior teeth; (4) a Class II molar relation; (5) large overjet; (6) TMJOA; and (7) a gummy smile. Based on these findings, skeletal maxillary protrusion associated with TMJOA was diagnosed.

Clinical Procedures and Outcomes

Surgical orthodontic treatment was selected to correct the severe Class II skeletal discrepancy, gummy smile, and facial profile. Surgical orthodontic treatment was to comprise bilateral mandibular first premolar extraction, with two-jaw surgery and genioplasty to improve the inclination of the labial side of the anterior mandibular teeth, acquire posterior space for eruption of the mandibular second molar, and achieve sufficient advancement of the mandible. It was also decided to extract the bilateral mandibular third molars before commencing pre-surgical orthodontic treatment.

Orthodontic treatment was performed with a multibracket system using a 0.022-slot pre-adjusted edgewise appliance. In pre-surgi-

Fig. 5 Pre-surgical facial and intraoral photographs at age 23y9m

cal orthodontic treatment, the orthodontic appliance was attached to the lower arch after extracting the bilateral mandibular first premolars. The size of the wire, which was initially 0.016-NiTi, was sequentially increased, and leveling and alignment up to a 0.019 $\times$ 0.025-NiTi wire performed. At 7 months after initiating treatment, distal movement of the mandibular canines was commenced with a 0.018 $\times$ 0.025-SS wire. After 8 months, the orthodontic appliance was attached to the upper arch and leveling and alignment initiated. After 1 year and 3 months, lingual movement of the mandibular anterior teeth was initiated with a 0.019 $\times$ 0.025-SS wire. After 2 years and 1 month, a 0.019 $\times$ 0.025-SS wire was applied to the upper and lower arches as the ideal arch wire (Fig. 5). At 2 years and 11 months, in the maxilla, the ANS was moved 6 mm upwards and the PNS 1 mm upwards by LeFort I osteotomy. In the mandible, the Pogonion was moved 17 mm anteriorly and 5 mm upwards with counterclockwise rotation by sagittal splitting ramus osteotomy. 3 years and 10 months later, the Pog was moved 6 mm forward by genioplasty. For post-surgical orthodontic treatment, a Class II intermaxillary elastic and vertical elastic were used

in the anterior tooth region. At 4 years after initiating orthodontic treatment, satisfactory occlusion and facial feature amelioration were achieved, and active orthodontic treatment was concluded (Figs. 6–8).

For retention after active treatment, the upper arch was maintained in a vertical position by using a circumferential type retainer and attaching a spur to the maxillary second molar (Fig. 9). Circumferential and fixed type retainers were used together in the lower arch.

Cephalometric analysis of the skeletal pattern revealed that the maxilla had not moved anteroposteriorly; the mandible had become almost standard, however, with a facial angle of 82–91° and SNB of 75–81°. As a result, convexity improved from 30 to 13°, and the ANB from 14 to 8°. In addition, vertically, the mandibular plane angle was almost standardized, from 42 to 36°, as was the Y-axis, from 70 to 62°. In the denture pattern, the U-1 to FH plane improved from 112 to 107°, the L-1 to FH plane from 38 to 61°, and the L-1 to mandibular plane from 100 to 83°. Therefore, labial inclination of the maxillary and mandibular anterior teeth improved (Figs. 4, 10). No significant change was observed in the

Fig. 6 Post-treatment facial photographs at age 25y2m

Fig. 7 Post-treatment intraoral photographs at age 25y2m

Fig. 8 Post-treatment panoramic radiograph at age 25y2m

Fig. 9 A circumferential type retainer with attached spur

skeletal or dental pattern at 2 years after completion of treatment (Figs. 10–12). Panoramic findings revealed no apparent morphological change in the condyle or articular

eminence (Fig. 13).

Fig. 10 Superimposition of pre-, post-treatment, and post-retention tracings on cephalometric radiographs

Solid line: pre-treatment at age 20y10m. Dashed line: post-treatment at age 25y2m. Dotted line: post-retention at age 27y2m.

Fig. 11 Post-retention facial photographs at age 27y2m

Discussion

Temporomandibular joint osteoarthritis is a degenerative disease characterized by progressive degradation of cartilage, remodeling of subchondral bone, synovitis, and chronic pain. The etiology of the majority of cases of TMJOA is complex, however, being multifactorial or unknown^{5,18}. Potential causative mechanisms of TMJOA include a decrease in the adaptive capacity of the TMJ tissues and sustained stress on the TMJ tissues that

exceeds the normal adaptive capacity^{1,2,16}. The clinical diagnosis of TMJOA is mainly based on the radiographic features of the condyle and articular eminence, including erosive resorption, sclerosis, attrition, osteophyte formation, and cyst-like change¹⁸.

The present patient had a history of TMJ symptoms and, because panoramic radiographs indicated a reduction in the mandibular ramus due to flattening of the condylar head, erosion, and osteophytes, TMJOA was diagnosed. Previous studies^{4,14} have reported

Fig. 12 Post-retention intraoral photographs at age 27y2m

Fig. 13 Post-retention panoramic radiograph at age 27y2m

No clear morphological change was observed in condyle or articular eminence at 2y after treatment completion.

that patients with TMJOA had mandibular ramus deficiency, a skeletal Class II relationship, a larger gonial angle, clockwise rotation of the mandible, a retrognathic facial profile, and a vertically elongated facial pattern. This patient had a similar maxillofacial morphology, and surgical correction was necessary to achieve morphologic improvement that would address the chief complaints concerning occlusion and the soft tissue profile, and which would establish functional occlusion to prevent further TMJOA-induced deterioration.

Surgical orthodontic treatment for skeletal Class II due to mandibular retrusion may involve advancement of the mandible. Achiev-

ing occlusal stability is difficult in such cases, however, in comparison with achieving setback of the mandible⁸⁾. Factors considered indicative of post-surgical skeletal relapse include how much the mandible is to be advanced, the surgical technique to be employed, bone fragment fixation, intraoperative condylar head positioning, the influence of extended suprahyoid muscles, and the morphology of the mandible, such as the inclination angle of the mandibular plane¹¹⁾. Moreover, PCR, a potential cause of relapse, can occur after orthognathic surgery⁹⁾. In addition to patient-related factors, those related to the onset of PCR, including rapid extension of the soft tissue, excessive load on the condylar head due to lateral deviation of the proximal bone fragment, poor circulation due to extensive separation of muscle and periosteum, and post-surgical occlusal stability, may be considered⁹⁾. Reportedly, stability is difficult to achieve when the mandible is to be advanced by ≥ 7 mm, or when the amount of counterclockwise rotation is to be large^{8,17)}. Therefore, two-jaw surgery is indicated in patients with a large facial height who require counterclockwise rotation of the mandible. In such cases, relapse is further reduced by upward movement of the mandible¹⁵⁾.

In avoiding post-surgical relapse or PCR, it is particularly desirable to advance the mandible as little as possible. In such cases, a num-

ber of surgical options are available, including advancement of the mandible only or in combination with anterior maxillary alveolar osteotomy. The present patient had vertical maxillary excess and a reduced vertical dimension of the mandibular ramus, however, and strongly desired reduction of the gummy smile and mandibular retrusion. Therefore, first, dental compensation was addressed by extraction of the mandibular premolar during pre-surgical orthodontic treatment. Next, vertical maxillary excess was adjusted, advancement of the mandible increased, and mandibular retrusion improved as much as possible through upward movement of the maxilla by orthognathic surgery and counter-clockwise rotation of the occlusal plane. In addition, augmentation of the chin was achieved by genioplasty.

Moreover, in surgical splint creation in model surgery, overbite and overjet were set to be small and overcorrection performed by creating a 1-mm vertical space in the molar region to prevent relapse, while ensuring the closeness of intercuspation by orthodontic treatment. To minimize the load on the TMJ during post-surgical orthodontic treatment, a weak Class II intermaxillary elastic and anterior tooth vertical elastic were employed over an extended period.

Appropriate overjet and overbite and favorable occlusion were achieved, marked retrusion and tension and the gummy smile ameliorated, and favorable facial morphology attained on completion of active treatment. The patient could perform natural lip closure and the tongue position had improved. The patient blushed during conversation on his initial visit to our department, could not make eye contact, and appeared to have a more introverted personality, as indicated by his covering his mouth with his hand. After treatment, he became more positive and cheerful, however, and could smile naturally.

Regarding Class III occlusion, one orthodontic treatment method is non-extraction in the maxilla and extraction of the first premolars in the mandible. Class III reversed occlusion, labial inclination and crowding of

the mandibular anterior teeth, no malalignment in the tooth axis or maxillary anterior teeth, and the presence and normal eruption of the mandibular third molars are considered desirable in such cases^{6,7,10}. Class III occlusion was originally an option in orthodontic treatment in cases of skeletal mandibular protrusion in which surgical orthodontic treatment was indicated. This method offers a non-surgical option in patients who are ineligible for surgery due to physical reasons or those who do not strongly desire a change in facial appearance. In orthodontic clinical practice, however, excessive lingual inclination of the anterior mandibular teeth can occur and stable occlusion be difficult to achieve¹³. If the mandibular third molar cannot be used, occlusal support cannot be obtained *via* the maxillary second molar; therefore, it is rarely selected as a therapeutic goal.

Some studies have reported surgical orthodontic treatment involving advancement of the mandible in patients with mandibular retrusion^{3,5,11}; however, to our knowledge, no case report has been published to date concerning extraction of the mandibular first premolar. The present patient had a +5 mm space in the maxilla, and the angle of inclination of the tooth axis of the anterior maxillary teeth was within the standard range. Extraction of the mandibular first premolar was selected as surgical orthodontic treatment for the Class III molar relation. This was done to improve the mandibular anterior tooth axis and achieve sufficient posterior space for eruption of the mandibular second molar and adequate advancement of the mandible. A sufficient improvement in the facial features was achieved by this approach. In the future, surgical orthodontic treatment may be indicated in patients with mandibular retrusion. In the present patient, however, the mandibular third molar had to be extracted during orthognathic surgery, and no vertical support for the maxillary second molar could be set. Although a retainer with a spur was used to prevent elongation, post-retention elongation of the second molar of the maxilla

was observed. Therefore, further follow-up examinations are planned.

At 2 years after completion of treatment, occlusion and the maxillofacial morphology have remained stable, with almost no relapse. Furthermore, no symptoms of TMJ disorder have manifested. In the future, careful observation of retention, including follow-up observation of elongation of the maxillary second molar and TMJOA, will be performed.

Conflict of Interest

The authors wish to report no conflict of interest with regard to this case report.

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References

- 1) Arnett GW, Milam SB, Gottesman L (1996) Progressive mandibular retrusion—idiopathic condylar resorption. Part I. *Am J Orthod Dentofacial Orthop* 110:8–15.
- 2) Arnett GW, Milam SB, Gottesman L (1996) Progressive mandibular retrusion—idiopathic condylar resorption. Part II. *Am J Orthod Dentofacial Orthop* 110:117–127.
- 3) Canaveral C, Zanella E, Medeiros PJD, Cappelli J Jr (2009) Surgical-orthodontic treatment of Class II malocclusion with maxillary vertical excess. *J Clin Orthod* 43:387–392.
- 4) Chen S, Lei J, Fu KY, Wang X, Yi B (2015) Cephalometric analysis of the facial skeletal morphology of female patients exhibiting skeletal Class II deformity with and without temporomandibular joint osteoarthritis. *PLoS ONE* 10: e0139743. doi: 10.1371/journal.pone.0139743.
- 5) Choi SH, Cha JY, Kang DY, Hwang CJ (2012) Surgical-orthodontic treatment for skeletal Class II malocclusion with vertical maxillary excess, anterior open bite, and transverse maxillary deficiency. *J Craniofac Surg* 23: e531–e535.
- 6) Farret MMB, Farret MM, Farret AM (2009) Strategies to finish orthodontic treatment with a Class III molar relationship: Three patient reports. *World J Orthod* 10:323–333.
- 7) Hirato R (1987) Clinical considerations on orthodontic cases requiring unusual alignment of the teeth. *Proceedings of the Bioprogressive Study Club in Japan* 1:63–85. (in Japanese)
- 8) Joss CU, Vassalli IM (2009) Stability after bilateral sagittal split osteotomy advancement surgery with rigid internal fixation: A systematic review. *J Oral Maxillofac Surg* 67:301–313.
- 9) Kobayashi T, Izumi N, Kojima T, Sakagami N, Saito I, Saito C (2012) Progressive condylar resorption after mandibular advancement. *Br J Oral Maxillofac Surg* 50:176–180.
- 10) Kosaka H (2002) Class III finish by mandibular first premolar extraction, Seeking a consensus for Class III treatment, Sugawara J, Asano T, 1st ed., pp.281–292, Tokyo Clinical Publications, Osaka. (in Japanese)
- 11) Kunimatsu R, Asakawa Y, Mitsuyoshi T, Oki N, Okamoto Y, Gunji H, Ohtani J, Tanimoto K (2015) A patient with maxillary protrusion accompanied with open bite treated by bimaxillary orthognathic surgery. *J Chu-shi Orthod Soc* 27:61–72. (in Japanese)
- 12) Manfredini D, Segù M, Arveda N, Lombardo L, Siciliani G, Rossi A, Guarda-Nardini L (2016) Temporomandibular joint disorders in patients with different facial morphology: A systematic reviews of the literature. *J Oral Maxillofac Surg* 74:29–46.
- 13) Nangia A, Darendeliler MA (2001) Finishing occlusion in Class II or Class III molar relation: Therapeutic Class II and III. *Aust Orthod* 17: 89–94.
- 14) Papadaki ME, Tayebaty F, Kaban LB, Troulis MJ (2007) Condylar resorption. *Oral Maxillofac Surg Clin North Am* 19:223–234.
- 15) Simmons KE, Turvey TA, Phillips C (1992) Surgical-orthodontic correction of mandibular deficiency: five-years follow-up. *Int J Adult Orthodon Orthognath Surg* 41:67–79.
- 16) Tanaka E, Detamore MS, Mercuri LG (2008) Degenerative disorders of the temporomandibular joint: Etiology, diagnosis, and treatment. *J Dent Res* 87:296–307.
- 17) Van Sickels JE, Richardson DA (1996) Stability of orthognathic surgery: A review of rigid fixation. *Br J Oral Maxillofac Surg* 34:279–285.
- 18) Wang XD, Zhang JN, Gan YH, Zhou YH (2015) Current understanding of pathogenesis and

- treatment of TMJ osteoarthritis. J Dent Res 94: 666–673.
- 19) Wolford LM, Chemello PD, Hilliard F (1994) Occlusal plane alteration in orthognathic surgery—Part I: Effects on function and esthetics. Am J Orthod Dentofacial Orthop 106:304–316.

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