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Analysis of postsurgical relapse patterns in one-jaw surgery: skeletal factors and clustering analysis in patients with mandibular setback

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Abstract (J Korean Assoc Oral Maxillofac Surg 2024;50:253-258)

Objectives: To compare presurgical skeletal factors and postsurgical relapse patterns between more relapsed (MR) and less relapsed (LR) groups.
Materials and Methods: This study retrospectively examined patients who underwent mandibular setback surgery, classifying them into two groups based on the amount of relapse of the pogonion using K-means analysis. Comparisons were conducted by analyzing cephalometric radiographs presurgically (T0), at 1-month post-surgery (T1), and immediately after orthodontic treatment (T2).
Results: The MR group at T0 had a lower articular angle and AB to the mandibular plane angle (MPA), higher gonial angle, shorter anterior and posterior facial heights, and shorter Frankfort horizontal plane to the upper incisor and first molar. The articular angle in the MR group increased postoperatively. The Frankfort MPA (FMA) did not differ significantly between the MR and LR groups.
Conclusion: Acute articular angle and short facial height with a high gonial angle in the presurgical stage can predict surgical relapse regardless of the FMA.

Key words: Prognathism, Orthognathic surgery, Recurrence

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I. Introduction

Mandibular setback surgery is primarily recommended in cases of severe mandibular prognathism. This surgery was developed from several techniques such as sagittal split ramus osteotomy (SSRO) and intraoral vertical ramus osteotomy after mandibular body osteotomy in the 1900s[1,2].

Although surgical treatment can improve the profile of patients with mandibular prognathism, surgical relapse should be considered to achieve stable surgical results because environmental factors, such as muscular forces around the mandible and tongue and surgical factors including bone fixation methods, amounts of surgical correction, and surgical technique may affect stability[3-5]. Other factors, such as condylar displacement and rotation of the proximal segments, can affect surgical relapse[6].

A previous study demonstrated that surgical relapse may be related to skeletal facial patterns[7], which could be relevant to the masticatory muscles, surgical design, and amount of mandibular setback[4]. However, there are several challenges in determination of the relationship between amount of surgical relapse and surgical correction[8-11].

In this study, presurgical skeletal factors and postsurgical relapse patterns were compared between more relapsed (MR) and less relapsed (LR) groups, which were classified using clustering analysis. Furthermore, the factors contributing to relapse after orthognathic surgery were investigated.

II. Materials and Methods

The study included 25 patients (15 males and 10 females) who underwent mandibular setback one-jaw surgery at Seoul National University Bundang Hospital. Patients with

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mandibular asymmetry were excluded. The mean patient age was 25.6 years. The SSRO for correction of mandibular prognathism was performed in all these patients. The average amount of mandibular setback was 7.41±4.45 mm. Plates and monocortical screws were used for osseous fixation, and intermaxillary fixation was applied with a stainless steel wire for 2 weeks. Functional jaw exercises were prescribed to patients for 2 weeks after intermaxillary fixation release.

Lateral cephalograms of each patient were obtained presurgically (T0), at 1 month after surgery (T1), and immediately after orthodontic treatment (T2) for analysis. The cephalogram analysis program NUSMA for Ceph was used in each of three sessions by two orthodontists. The landmarks, reference planes, and variables comprising the linear and angular measurements are shown in Fig. 1, 2.

The horizontal measurements for the analysis of anterior and posterior changes were the distance between each landmark point and the perpendicular line of the sella (S) to the Frankfort horizontal (FH) plane (S-perp) line, mandibular body length, SNB angle, and AB to the MPA. Vertical measurements included the distance from the FH plane to each landmark point and the posterior and anterior facial heights. To evaluate rotational changes in the mandible, the articular angle, gonial angle, and Frankfort-mandibular plane angle (FMA) were measured.

To analyze the upper and lower anterior tooth axes, the angle between the long axis of the U1 and the FH plane, angle between the lower incisor and mandibular plane, angle between the FH plane and the upper or lower occlusal plane, and distance between the U1 tip and the mesiobuccal cusp tip of the U6 were measured.

Statistical analysis was performed using K-means clustering to classify the patients into the MR and LR groups. The values at T0 were analyzed using an independent *t*-test to compare presurgical skeletal factors between the MR and LR groups. Other measurements of surgical changes (T1-T0) and postsurgical relapse (T2-T1) were analyzed using an independent *t*-test. Statistical significance was set at $P<0.05$.

This study was conducted in accordance with the tenets of the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of Bundang Hospital (IRB No. B-1302-192-101).

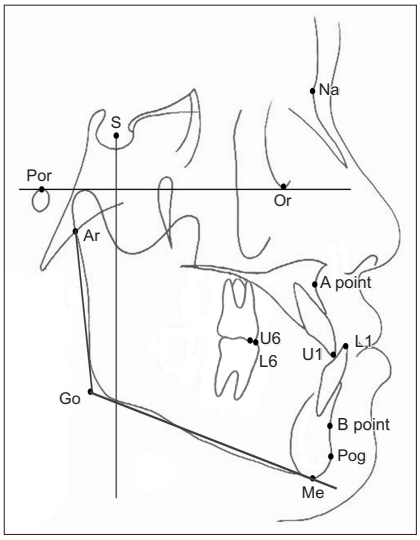

Fig. 1. Landmarks for analysis.
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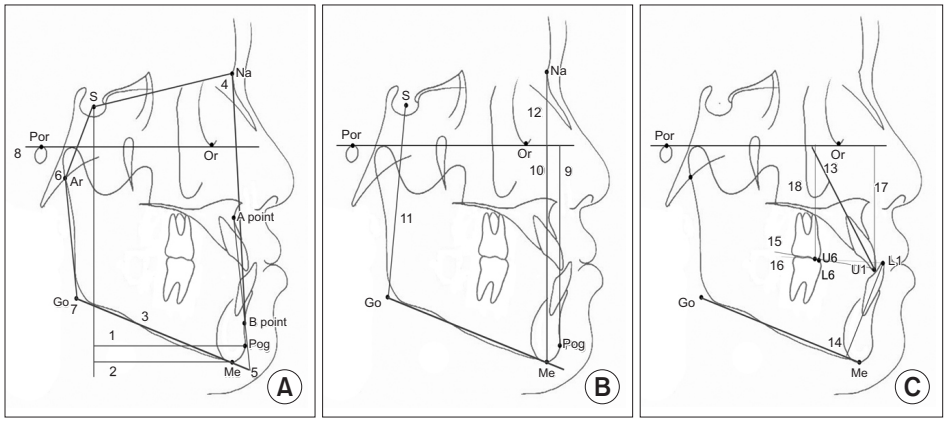

Fig. 2. Measurements for analysis. A. Mandibular anterior/posterior and angular measurements. B. Vertical measurements. C. Dental measurements.
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III. Results

Anterior and posterior relapse distances of the Pog were 4.45±1.26 mm in the MR group and 1.34±1.07 mm in the LR group, which were classified by K-means clustering analysis with measurements of S-perp to Pog.(Table 1) There were 12 and 13 patients in the MR and LR groups, respectively.

Presurgical (T0) factors that were significantly different between the MR and LR groups were the AB to the MPA in the mandibular anterior and posterior measurements, FH plane to Pog, FH plane to Me, posterior facial height, and anterior facial height in vertical measurements, articular angle and gonial angle in angular measurements, and FH to U1 and FH to U6 in dental measurements.(Table 2)

The MR group exhibited a shorter presurgical vertical orientation compared to the LR group. Although the FMA angle of the MR group did not significantly differ from that of the LR group, the articular angle was larger and the gonial angle was smaller in the MR group.

Mandibular anterior and posterior measurements, such as the AB to the MPA, were significantly different between the MR and LR groups.

The measurements related to surgical changes (T1-T0) were not significantly different between the MR and LR groups, except for those of the AB to the MPA and articular angle, as shown in Table 3.

In postsurgical relapse, the MR group exhibited significant decrease in FH to Pog and FH to Me and significant increase in S-perp to Pog, S-perp to Me, and SNB (P<0.05). The articular angle and AB to the MPA in the MR group decreased more than those in the LR group. The UI to the FH and the FH to the upper occlusal plane in the MR group were significantly different from those in the LR group, as shown in Table 4 (P<0.05).

Table 1. Anterior and posterior relapse of Pog in the MR group and LR group by linear measurement of a perpendicular line of the sella to Pog

	MR group	LR group	*P*-value
Relapse of Pog (mm)	4.45±1.26	1.34±1.07	<0.001
No. of subjects	12	13	-

(MR: more relapsed, LR: less relapsed)
Values are presented as mean±standard deviation or number only.
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IV. Discussion

In this study, presurgical skeletal factors, including presurgical orthodontic period and postsurgical relapse patterns, were analyzed between the MR and LR groups, classified using clustering analysis.

The MR group exhibited mandibular anterior relapse even

Table 2. Presurgical (T0) cephalometric analysis of the MR group and LR group

Measurements	MR group		LR group		Sig.
	Mean	SD	Mean	SD	
Mandibular anterior and posterior measurements					
S-perp to Pog (mm)	82.02	8.54	80.16	8.88	NS
S-perp to Me (mm)	76.05	8.85	73.93	9.65	NS
Mn body length (mm)	83.63	4.01	86.82	4.58	NS
SNB (°)	84.40	2.98	82.92	4.05	NS
AB to Mn plane angle (°)	55.04	4.45	60.86	4.71	0.004
Angular measurements					
Articular angle (°)	139.42	6.83	146.06	8.07	0.037
Gonial angle (°)	126.19	5.87	121.25	4.44	0.026
FMA (°)	21.94	6.47	21.94	4.45	NS
Vertical measurements					
FH to Pog (mm)	91.49	6.85	99.13	7.66	0.015
FH to Me (mm)	100.90	7.47	109.22	7.88	0.013
Post. facial height (mm)	88.86	8.83	97.06	7.43	0.019
Ant. facial height (mm)	133.47	8.26	142.15	8.40	0.016
Dental measurements					
U1 to FH (°)	120.26	6.53	119.84	7.26	NS
IMPA (°)	83.18	9.49	86.88	6.30	NS
FH to U occlusal plane (°)	7.94	5.54	6.30	3.10	NS
FH to L occlusal plane (°)	4.22	5.68	4.46	4.23	NS
FH to U1 (mm)	57.43	4.01	61.38	4.68	0.034
FH to U6 (mm)	53.28	2.89	57.85	4.40	0.006

(MR: more relapsed, LR: less relapsed, SD: standard deviation, Sig.: significant in the independent *t*-test, NS: not significant, FH: Frankfort horizontal, S-perp: a line perpendiculat to FH plane through Sella, FMA: Frankfort-mandibular plane angle, Post.: posterior, Ant.: anterior, IMPA: incisor mandibular plane angle)
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though the mandibular body length was shorter than that in the LR group at T0. The amount of surgical change and relapse of mandibular body length were similar in the groups. These results demonstrated that other presurgical factors may affect surgical relapse in patients with mandibular prognathism. The MR group revealed different skeletal patterns, with a vertically shorter face than that of the LR group. The FH to the Pog, FH to the Me, and anterior and posterior facial heights were significantly lower in the MR group compared to the LR group. This pattern was observed in the dental mea-

Table 3. Cephalometric analysis of surgical changes (T1-T0) of the MR group and LR group

Measurements	MR group		LR group		Sig.
	Mean	SD	Mean	SD	
Mandibular anterior and posterior measurements					
S-perp to Pog (mm)	–11.58	3.20	–10.43	4.36	NS
S-perp to Me (mm)	–12.19	3.46	–10.60	4.94	NS
Mn body length (mm)	–7.04	4.75	–7.75	4.18	NS
SNB (°)	–5.91	1.29	–4.99	1.66	NS
AB to Mn plane angle (°)	12.67	2.42	9.04	2.67	0.002
Angular measurements					
Articular angle (°)	4.36	3.88	1.52	1.80	0.026
Gonial angle (°)	–1.94	6.18	1.94	5.20	NS
FMA (°)	2.36	3.23	3.38	4.83	NS
Vertical measurements					
FH to Pog (mm)	–0.02	2.69	1.59	2.47	NS
FH to Me (mm)	0.16	2.37	–0.86	2.16	NS
Post. facial height (mm)	–0.31	2.29	–0.44	4.49	NS
Ant. facial height (mm)	–0.29	2.13	0.94	2.30	NS
Dental measurements					
U1 to FH (°)	–0.72	1.81	–1.46	3.57	NS
IMPA (°)	–2.83	4.74	–1.81	3.06	NS
FH to U occlusal plane (°)	0.07	1.45	–0.06	2.11	NS
FH to L occlusal plane (°)	2.73	6.52	2.37	6.31	NS
FH to U1 (mm)	0.02	0.84	0.46	1.31	NS
FH to U6 (mm)	–0.04	0.91	0.50	1.02	NS

(T1: 1 month after surgery, T0: presurgical, MR: more relapsed, LR: less relapsed, SD: standard deviation, FH: Frankfort horizontal, Sig.: significant in the independent *t*-test, NS: not significant, S-perp: a line perpendiculat to FH plane through Sella, FMA: Frankfort-mandibular plane angle, Post.: posterior, Ant.: anterior, IMPA: incisor mandibular plane angle)

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Table 4. Cephalometric analysis of postsurgical relapse (T2-T1) of the MR group and LR group

Measurements	MR group		LR group		Sig.
	Mean	SD	Mean	SD	
Mandibular anterior and posterior measurements					
S-perp to Pog (mm)	4.45	1.26	1.34	1.07	<0.001
S-perp to Me (mm)	5.15	1.76	1.05	1.34	<0.001
Mn body length (mm)	1.62	3.72	2.21	2.47	NS
SNB (°)	1.93	0.79	0.75	0.68	0.001
AB to Mn plane angle (°)	–4.15	2.28	–2.37	2.19	NS
Angular measurements					
Articular angle (°)	–3.08	2.81	–0.54	1.25	0.012
Gonial angle (°)	2.79	3.08	1.38	2.53	NS
FMA (°)	–0.79	2.48	1.14	2.33	NS
Vertical measurements					
FH to Pog (mm)	–3.14	2.44	–1.50	0.88	0.046
FH to Me (mm)	–2.64	1.66	–1.55	0.90	0.050
Post. facial height (mm)	–2.46	2.62	–3.84	2.83	NS
Ant. facial height (mm)	–2.58	1.52	–1.56	1.17	NS
Dental measurements					
U1 to FH (°)	3.34	4.07	–0.31	4.21	0.038
IMPA (°)	0.34	6.33	1.09	3.51	NS
FH to U occlusal plane (°)	–1.46	3.28	1.58	2.52	0.016
FH to L occlusal plane (°)	–3.85	4.32	–1.18	3.49	NS
FH to U1 (mm)	–0.86	1.70	0.28	1.10	NS
FH to U6 (mm)	–0.14	0.85	–0.67	1.11	NS

(T2: immediately after orthodontic treatment, T1: 1 month after surgery, MR: more relapsed, LR: less relapsed, SD: standard deviation, Sig.: significant in the independent *t*-test, NS: not significant, S-perp: a line perpendiculat to FH plane through Sella, FMA: Frankfort-mandibular plane angle, FH: Frankfort horizontal, Post.: posterior, Ant.: anterior, IMPA: incisor mandibular plane angle)

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surements of FH to UI (mm) and FH to U6 (mm). Although the gonial angle in the MR group was larger than that in LR group, the articular angle in the MR group was smaller than that in the LR group. A high gonial angle can induce an increase in the total mandibular length from the articulare to the Me or Pog. A smaller articular angle could result in shorter facial height anteriorly and posteriorly, which may indicate a shorter facial height with a longer mandibular length. In addition, this led to a decrease in the AB to the MPA.

During surgery, the MR group tended to exhibit larger posterior shifts of the Pog, Me, and B points and smaller decrease in the mandibular body length in the anterior and posterior measurements of the mandible. The greater tendency for posterior mandibular movement in the MR group, without a greater decrease in the length of the mandibular body, likely is related to a greater increase in the articular angle during surgery. In both groups, the articular angle increased, but the MR group revealed a significant increase, indicating that the posterior movement of the mandible created larger positional changes with an increasing articular angle compared to a reduction in the length of the mandible in that group.

Although the shape of the face in the MR group could be narrow at the front, this facial pattern may be brachyfacial, potentially resulting in strong masticatory muscles and heavy bite forces because of the low articular angle and short facial height[7,12]. In the MR group, an increase in the articular angle during surgery was expected to increase the resistance to the strong masticatory muscles, resulting in a higher magnitude of counterclockwise rotation of the mandible. This could cause postsurgical vertical relapse, as shown in the FH to Pog, FH to Me, and articular angle. These measurements decreased with mandibular forward relapse, as seen in previous studies that reported relation of the forward-upward rotation of the mandible after mandibular surgery to most of the forward movement of the chin[13].

The FMA was not related to significant presurgical factors when classifying the facial types in this study. Postsurgical change of mandibular body length in the MR group (1.62±3.72 mm) did not significantly differ from that of the LR group (2.21±2.47 mm). The Pog and Me points were moved anteriorly approximately 4.45 mm and 5.15 mm, respectively, which were significantly larger than those in the LR group (P<0.05). This indicates that mandibular rotation after surgery due to heavy bite forces in the MR group could contribute more highly to postsurgical relapse than actual pure surgical relapse, such as an increase in the mandibular body length[14]. This demonstrates that postsurgical relapse could be more related to the presurgical skeletal pattern than to surgical fixation or the extent of setback surgery. Other research concerning mandibular setback surgery with a metal plate system revealed no relation to relapse in mandibular setback[15]. However, vertical relapse in the counterclockwise direction may occur after mandibular setback surgery and is significantly correlated with forward relapse of the chin[16].

The effects of strong muscle forces were observed not only in vertical measurements, but also in U1 to FH and FH to the upper occlusal plane. The heavy bite force after surgery in the MR group may have induced changes in the upper dentition, such as labial inclination of the upper anterior teeth and counterclockwise rotation of the upper occlusal plane. In other words, upward and forward rotation of the mandible with the hinge axis of the condyle and changes in the upper occlusal plane occur frequently during occlusal settling after surgery[17].

Therefore, pre-surgical skeletal factors, such as vertical measurements, articular angle, gonial angle, and AB to the MPA, could help clinicians classify the skeletal pattern, estimate the masticatory force and habit of patients, predict relapse, and create a surgical plan to reduce the relapse of mandibular setback surgery.

V. Conclusion

In conclusion, an acute articular angle and short facial height with a high gonial angle in the presurgical stage can help predict surgical relapse, regardless of the FMA. Postsurgical relapse could be more highly related to the presurgical skeletal pattern than to surgical fixation or the extent of setback surgery. Masticatory forces incurred during function and habits in the presurgical stage may affect relapse after surgery.

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Authors' Contributions

J.W.K. participated in the study design, data analysis, investigation, methodology, and writing of the original draft. N.K.L., P.Y.Y., and J.H.L. participated in the study design,

data curation, and investigation. H.Y.S. participated in the study design, coordination, and revision of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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