Original Article

Hard and Soft Tissue Stability of Orthognathic Surgery

Sagittal Split Ramus Osteotomy and Intraoral Vertical Ramus Osteotomy

Toru Kitahara[a]; Akihiko Nakasima[b]; Shinichi Kurahara[c]; Yuji Shiratsuchi[d]

ABSTRACT

Objective: To test the hypothesis that there is no difference in the stability of the hard and soft tissue changes following a surgical mandibular setback using a sagittal split ramus osteotomy or an intraoral vertical ramus osteotomy.

Materials and Methods: The samples consisted of 45 female patients with mandibular prognathism, who were divided into two groups. Twenty-three underwent a sagittal split ramus osteotomy (SSRO) with rigid fixation by titanium mini-screws and maxillomandibular fixation (MMF) for 14.0 $\pm$ 0.7 days. Twenty-two underwent intraoral vertical ramus osteotomy (IVRO) without rigid fixation, and MMF was released 21.5 $\pm$ 3.3 days after surgery. Data were collected from standardized cephalometric radiographs taken at the start of preoperative orthodontic treatment (T1), immediately after surgery (MMF, T2), and the completion of postoperative treatment (T3). Angular measurements were compared on each of T1, T2, and T3.

Results: There were no significant differences in the pretreatment hard and soft tissue morphology between the SSRO and IVRO. However, when fixation was released, the mandible was posteriorly positioned in the IVRO group. In the soft tissue profile, the mental region was located backward in the IVRO group at postoperative stage (T3).

Conclusions: The hypothesis is rejected. The soft tissue profile of the IVRO group especially showed a retromandibular position after postoperative treatment in comparison with the SSRO group. This tendency of the IVRO group would contribute to the database for treatment planning and prediction. (*Angle Orthod.* 2009;79:158–165.)

KEY WORDS: Orthognathic surgery; Stability; Surgical mandibular setback; Class III malocclusion; Soft tissue analysis

INTRODUCTION

Orthognathic surgical techniques include both the intraoral vertical ramus osteotomy (IVRO) and sagittal split ramus osteotomy (SSRO), and both can be used to correct mandibular prognathism. However, SSRO has been performed more often because of the ability to apply rigid internal fixation with screw devices.

A number of studies have reported on the influence of various surgical techniques on the temporomandibular joint (TMJ).[1,2] Rigid fixation of the mandible during orthognathic surgery may result in a higher incidence of TMJ dysfunction when compared with the IVRO technique with nonrigid fixation. The IVRO technique has been used widely based on the rationale that it is useful for the patient that is developing temporomandibular dysfunction.[3,4] Later, the IVRO technique came to be applied for orthognathic surgical treatment of mandibular prognathism.

The purpose of this study was to investigate the treatment changes of the hard and soft tissue profile after two different types of mandibular osteotomy, and to provide further information about the changes in postoperative mandibular displacement.

[a] Assistant Professor, Division of Oral Health, Growth & Development, Faculty of Dental Science, Kyushu University, Fukuoka, Japan.

[b] Professor, Division of Oral Health, Growth & Development, Faculty of Dental Science, Kyushu University, Fukuoka, Japan.

[c] Assistant Professor, Section of Oral & Maxillofacial Surgery, Division of Maxillofacial Diagnostic and Surgical Sciences, Faculty of Dental Science, Kyushu University, Fukuoka, Japan.

[d] Associate Professor, Section of Oral & Maxillofacial Oncology, Division of Maxillofacial Diagnostic and Surgical Sciences, Faculty of Dental Science, Kyushu University, Fukuoka, Japan.

Corresponding author: Toru Kitahara, DDS, PhD, Department of Orthodontics, Faculty of Dentistry, Kyushu University, 3-1-1 Maidashi, Higashi-ku, Fukuoka 812-8582 Japan (e-mail: kitahara@dent.kyushu-u.ac.jp)

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Table 1. Summary of Sagittal Split Ramus Osteotomy (SSRO) and Intraoral Vertical Ramus Osteotomy (IVRO) Group[a]

	SSRO (n = 23)				IVRO (n = 22)				
	Mean		SD		Mean		SD		Difference
Duration of presurgical orthodontic treatment	23.5	±	7.9	months	21.9	±	7.8	months	NS
Average age of operation	24.9	±	5.8	years	24.2	±	5.1	years	NS
Average amount of mandibular setback (point B)	9.9	±	3.2	mm	8.4	±	3.1	mm	NS
Duration of maxillomandibular fixation (MMF)	14.0	±	0.7	days	21.5	±	3.3	days	***
Duration of postsurgical orthodontic treatment	11.7	±	3.6	months	11.5	±	4.0	months	NS
Duration of overall orthodontic treatment	35.2	±	8.2	months	33.4	±	9.8	months	NS

[a] SD indicates standard deviation; NS, not significant.
*** $P = .001$.

MATERIALS AND METHODS

Subjects

All material was randomly selected from the files of 584 jaw deformation patients registered between 1990 and 2005 in Kyushu-University Hospital, Japan. The sample consisted of 45 women with mandibular prognathism treated with either SSRO (23 patients, mean age 24.9 ± 5.8 years) or IVRO (22 patients, mean age 24.2 ± 5.1 years) (Table 1). There was no significant difference in the age distribution in the two groups. No asymmetry case was contained in the sample. The criterion for deciding between SSRO and IVRO was the preference of the surgeon.

Preoperative and postoperative orthodontic treatment was performed on all patients. Maxillary teeth were extracted in 22 subjects to eliminate maxillary crowding and to reduce upper incisor proclination. In the mandibular arch, alignment and proclination of incisors were accomplished with nonextraction except in two patients.

The mean duration of preoperative orthodontic treatment of the SSRO group was 23.5 ± 7.9 months and of the IVRO group was 21.9 ± 7.8 months. In the SSRO group rigid fixation was used with two monocortical titanium screws (15.0 mm and 17.0 mm) on each side. Maxillomandibular fixation (MMF) was maintained for 14.0 ± 0.7 days postoperatively, followed by functional training with light-guiding elastics. In the IVRO no osseous fixation was used, but MMF was in place until a mean of 21.5 ± 3.3 days after surgery. There was a significant difference in the duration of MMF ($P < .001$) between the two groups. The average amount of mandibular setback at point B (9.9 ± 3.2 mm in the SSRO; 8.4 ± 3.1 mm in the IVRO) was not significantly different.

Measurement Methods

A lateral cephalogram was taken for each subject before preoperative orthodontic treatment (T1), immediately after surgery (T2), and at completion of the postoperative orthodontic treatment (T3).

All cephalograms were traced on acetate paper by the same investigator in order to eliminate interexaminer variability. For analysis, sella was used as the origin and a horizontal line passing through sella and parallel with the Frankfort horizontal (FH) plane was used as the x coordinate axis. A line perpendicular to the x coordinate axis and passing through sella was defined as the y coordinate axis. The 15 hard tissue angles and 3 soft tissue angles were calculated from the 25 anatomic landmarks on the cephalograms using cephalometric analyzing software (WinCEPH Version 5, Sendai, Japan) (Figures 1, 2). A soft tissue measurement of T2 was omitted because it was soon after the operation.

Error of the Method

The error of the method was evaluated by measuring the same cephalogram 27 times by the same person and calculating coefficients of variation for the values of each angle to estimate the accuracy of the method. The mean of the error, expressed by the coefficient of variation, was 1.81%. The method error was considered negligible.

Statistical Methods

The Student's *t*-test was used to compare the mean differences in the hard and soft tissue variables between the SSRO and IVRO groups using the statistical package JMP (SAS Institute, Release 6.0, Cary, NC). Changes in the coordinates of U1, L1, point B, Pg, Me, and Go after removal maxillomandibular fixation were assessed during T3-T2 follow-up (SSRO group: 1.0 ± 0.3 years, IVRO group: 1.0 ± 0.3 years). All changes of each x and y variable were analyzed using the paired *t*-test. Differences of $P \leq .05$ were considered significant.

In order to represent differences of the morphology between two groups visually, profile diagrams (profilograms) were produced using the 25 coordinate landmarks.

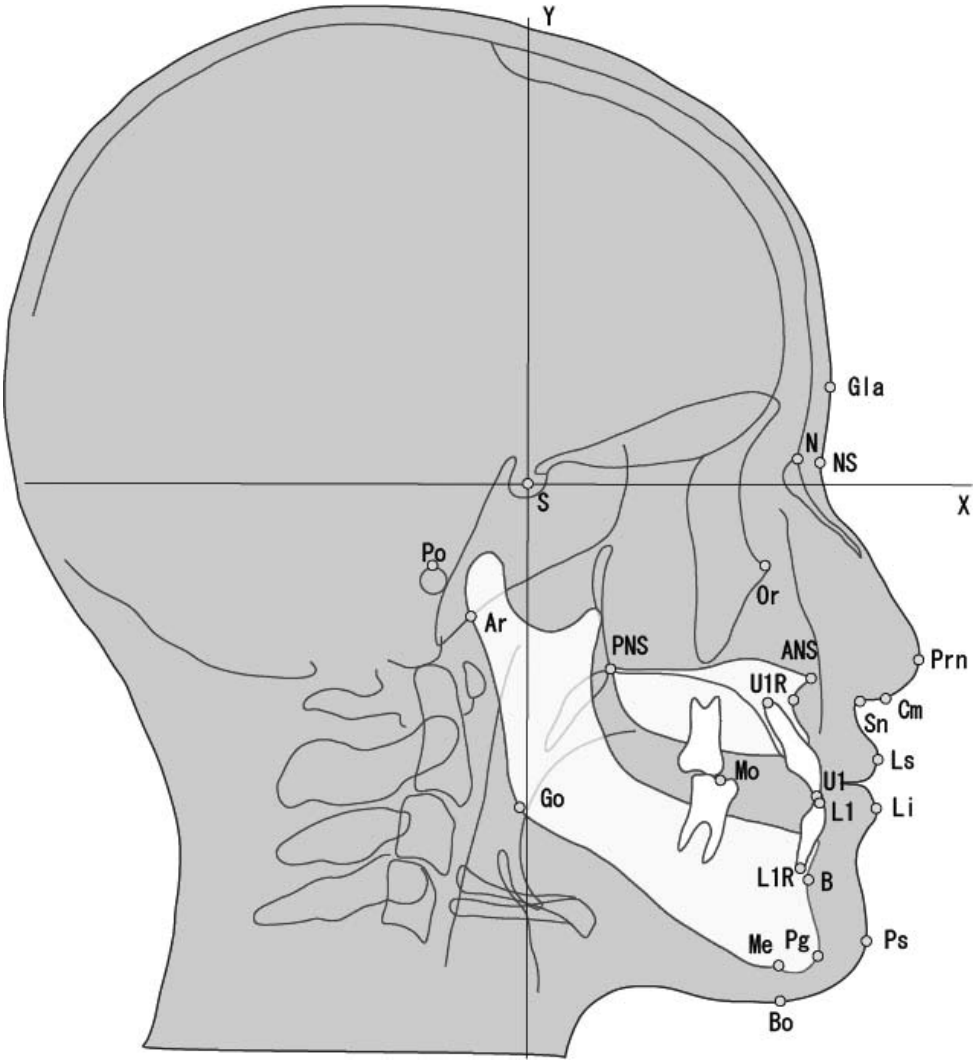

Figure 1. Skeletal and dental landmarks used in cephalometric analysis.

RESULTS

Comparison of Hard and Soft Tissue Angular Measurements Between SSRO and IVRO Groups

A comparison of the mean values and standard deviations of the hard and soft tissue variables between the three different observation periods at T1, T2, and T3 are presented in Table 2a, 2b, and 2c, respectively. No significant differences in the mean values of the hard and soft tissue variables were found between the SSRO and IVRO groups at T1 (Table 2a). In Table 2b, two significant differences in skeletal variables were observed in the convexity angle ($P < .05$) and ramus plane angle ($P < .001$) between the two groups at T2 (Table 2b). There were significant differences in skeletal measurements between the two groups at T3 in the facial plane angle ($P < .05$), convexity angle ($P < .001$), mandibular plane angle ($P < .001$), and gonial angle ($P < .001$). The differences in dental measurements were U1-SN ($P < .05$) and occlusal plane ($P < .05$). The soft tissue measurements differed between the groups in Gl-Sn–Sn-Ps ($P < .001$) and HP–Li-Ps ($P < .001$) (Table 2c).

Horizontal and Vertical Changes of Hard Tissue Landmarks After Surgery

Table 3 summarizes changes in the x and y coordinates of the hard tissue landmarks from T2 to T3. According to the cephalometric analysis, the average amount of mandibular setback at point B was 9.9 $\pm$ 3.2 mm in SSRO and 8.4 $\pm$ 3.1 mm in the IVRO group, which was not significantly different.

Significant horizontal postoperative changes in the SSRO group were found in all parameters except for Me, and significant vertical changes were found in all parameters except for point B and Pg. In the IVRO group, horizontal and vertical postoperative changes

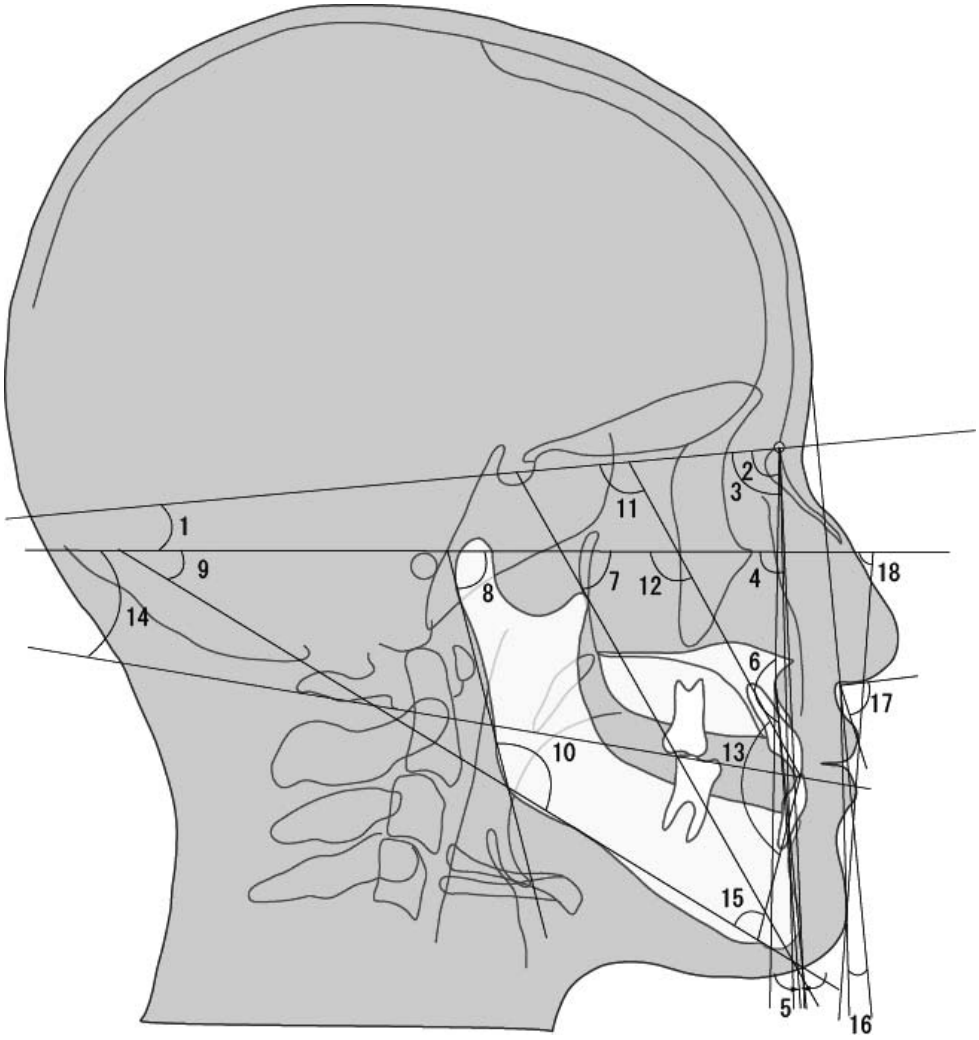

Figure 2. Measurements of hard and soft tissue in lateral cephalograms. Each parameter is measured as the size of the angle. Hard tissue: (1) FH-SN. (2) SNA. (3) SNB. (4) FH-facial. (5) AB-facial. (6) Convexity. (7) Y-axis. (8) FH-ramus. (9) FH-mandibular. (10) Gonial. (11) U1-SN. (12) U1-FH. (13) Interincisal. (14) FH-occlusal. (15) L1-mandibular. Soft tissue: (16) Gl-Sn–Sn-Ps. (17) Cm-Sn–Ls. (18) HP–Li-Ps.

in all parameters were significant except for U1, and remarkable changes were seen in the horizontal direction at point B ($P < .001$), Pg ($P < .001$), and Me ($P < .001$) and in the vertical direction at Me ($P < .001$). In the SSRO group, U1 moved forward and upward ($P < .01$), whereas no significant changes were found in the IVRO group. The mandibles in the IVRO group repositioned more posteriorly after surgery than those in the SSRO group. Go in the IVRO group moved forward and upward ($P < .01$, both), but Go in the SSRO moved backward and upward ($P < .05$, $P < .001$, respectively).

High levels of significant differences of horizontal postoperative changes between the SSRO and IVRO groups were found in all parameters. Postoperatively, significantly upward changes were found in U1 ($P < .05$) and Go ($P < .001$) in the SSRO group, whereas point B and Me were significantly upward ($P < .05$) in the IVRO group.

Graphic Comparison of Hard and Soft Tissue Between SSRO and IVRO Group

The profilograms of the SSRO and IVRO groups were superimposed at each time of treatment progress (Figure 3). There were almost no significant differences between the profilograms of the two groups at T1 (Figure 3a). At the T2 (MMF) stage, Pg and Me positioned more upward and backward in the IVRO group (Figure 3b). This tendency was maintained at the T3 stage (Figure 3c). The mandible was rotated upward and backward in the IVRO group, and the gonial angle was larger compared with those in the SSRO group at T3. Then, the soft tissue mental region was located backward in the IVRO group.

Table 2a. Comparisons Between Sagittal Split Ramus Osteotomy (SSRO) and Intraoral Vertical Ramus Osteotomy (IVRO) Groups in Angle Measurements (Degree) at Start of Preoperative Orthodontic Treatment (T1)[a]

	SSRO (n = 23)		IVRO (n = 22)		
	Mean	SD	Mean	SD	
Hard tissue measurements					
FH-SN	7.4	2.6	7.8	3.5	NS
SNA	81.1	3.6	81.5	4.3	NS
SNB	84.9	3.6	84.6	5.2	NS
Facial	92.1	2.6	91.8	4.7	NS
A-B	5.1	2.8	4.7	3.7	NS
Convex.	186.9	4.2	185.1	5.3	NS
Y-axis	60.5	2.4	60.7	4.9	NS
Ramus	78.4	4.5	78.9	5.8	NS
MPA	30.4	3.3	30.3	7.0	NS
Go	132	5.1	131.5	7.8	NS
U1-SN	110.8	5.9	112.2	6.5	NS
U1-FH	118.3	5.7	120	7.1	NS
Interinc.	134.9	9.2	131.3	8.5	NS
Occlusal plane	10.8	3.7	9.6	6.0	NS
L1-MPA	76.5	7	78.4	8.3	NS
Soft tissue measurements					
Gl-Sn–Sn-Ps	4	2.2	5.1	5.0	NS
Cm-Sn–Ls	87.1	10.1	88.5	10.5	NS
HP–Li-Ps	81.5	4.9	78.8	7.5	NS

[a] SD indicates standard deviation; NS, not significant.
* $P = .05$; ** $P = .01$; *** $P = .001$.

Table 2b. Comparisons Between Sagittal Split Ramus Osteotomy (SSRO) and Intraoral Vertical Ramus Osteotomy (IVRO) Groups in Angle Measurements (Degree) Immediately After Surgery (T2)[a]

	SSRO (n = 23)		IVRO (n = 22)		
	Mean	SD	Mean	SD	
Hard tissue measurements					
FH-SN	7.8	2.6	7.7	3	NS
SNA	81.1	3.6	81.9	4.7	NS
SNB	80.2	3.9	80.4	4.6	NS
Facial	88.4	2.5	87.8	4.4	NS
A-B	−1.6	2.3	−1.5	2.8	NS
Convex.	179.2	3.8	176.5	5.3	*
Y-axis	63.5	2.2	64.4	4.9	NS
Ramus	83.3	3.9	87.5	4.8	***
MPA	31.5	4	33	7.5	NS
Go	128.2	4.4	125.5	8.3	NS
U1-SN	109.5	5.6	106.7	7.6	NS
U1-FH	117.3	5.2	114.4	8.3	NS
Interinc.	127.7	6.9	129.4	8.3	NS
Occlusal plane	9.6	3.5	11.4	5.7	NS
L1-MPA	83.6	5.2	83.2	6.9	NS

[a] SD indicates standard deviation; NS, not significant.
* $P = .05$; ** $P = .01$; *** $P = .001$.

DISCUSSION

The Adaptation of the Surgical Technique

In the correction of mandibular position, SSRO has several advantages over the IVRO, including better bony interface between the segments, easier use of rigid fixation, and quicker recovery of oral function.[5] Abrahamsson et al[6] reported in a systematic review that no conclusion could be drawn if and how orthognathic surgery alters signs and symptoms of TMD. However, IVRO or modified condylotomy has been reported favorable to the TMJ because of the anterior-inferior repositioning of the condyle and the increase in joint space, with a chance of improved symptoms of the joint.[1,4] The most important advantage of the IVRO is the lower incidence of injury to the inferior alveolar nerve.[7]

The Evaluation of the Hard Tissue

Rivera et al[8] reported that patients underwent orthognathic surgery to improve esthetic, functional, and TMJ problems. However, these orthognathic surgery benefits are not always realized because of the relapse of the surgical changes. Measurable skeletal relapse after correction of mandibular prognathism occurs not only after release of intermaxillary fixation (later relapse), but also at a stage as early as the period of intermaxillary fixation (early relapse).[9] The present results demonstrate that changes in mandibular position occur during postoperative orthodontic treatment following mandibular setback surgery. Mobarak et al[10] observed SSRO with rigid fixation appears to be a fairly stable clinical procedure. Most of the relapse took place during the first 6 months after surgery. Eggensperger et al[11] observed there was similar skeletal relapse of 1 mm at the B-point and Pg amounting to 14% of the initial skeletal setback.[12]

The factors that explain the horizontal relapse after the SSRO include the magnitude of the setback, the method of fixation, remodeling or repositioning of the condyle, and forward pull of the pterygo-massteric sling.[12,13] Park et al[14] reported a 21% relapse rate in IVRO and 27.2% in SSRO patients. Ayoub et al[12] reported the main change was the mean forward relapse of 2.5 mm in the SSRO group and the mean posterior relapse of 0.5 mm in the IVRO group. They concluded that the difference in skeletal stability between the groups was significant ($P < .05$) and IVRO was the more effective technique for correcting mandibular prognathism. The present findings have similar results in that during the postoperative period there was a trend for posterior rotation of the mandible after the IVRO procedure.

Condylar repositioning is an option with the IVRO. Detachment of the masseter, temporalis, and a portion of the medial pterygoid muscle allow the condyle to move in an inferior and anterior direction under the influence of the lateral pterygoid muscle.[15] The con-

Table 2c. Comparisons Between Sagittal Split Ramus Osteotomy (SSRO) and Intraoral Vertical Ramus Osteotomy (IVRO) Groups in Angle Measurements (Degree) at Completion of Postoperative Orthodontic Treatment (T3)[a]

	SSRO (n = 23)		IVRO (n = 22)		
	Mean	SD	Mean	SD	
Hard tissue measurements					
FH-SN	7.1	2.3	7.5	3.4	NS
SNA	81.2	3.6	82	4.6	NS
SNB	80.3	3.8	79.3	4.5	NS
Facial	88.1	2.6	86.3	4.3	*
A-B	−2.2	2.2	−3	3.1	NS
Convex	179.2	3.5	173.9	4.2	***
Y-axis	63.8	2.6	65.4	4.8	NS
Ramus	83.4	5.8	82.4	4.7	NS
MPA	31	3.8	37.2	7.8	***
Go	127.6	6	134.8	8.4	***
U1-SN	109.5	7.5	105.5	7.3	*
U1-FH	116.7	7.4	113	8.4	NS
Interinc.	128.7	9	126.3	9	NS
Occlusal plane	9.9	4.2	12.8	5.1	*
L1-MPA	83.6	5.9	83.5	6.8	NS
Soft tissue measurements					
Gl-Sn–Sn-Ps	8.8	4	14	4.4	***
Cm-Sn–Ls	91.3	9.3	92.8	8.1	NS
HP–Li-Ps	77	5.2	69.4	6.8	***

[a] SD indicates standard deviation; NS, not significant.
* $P = .05$; ** $P = .01$; *** $P = .001$.

dyle can move beneath the articular disc in patients with anterior displaced discs, which indicates the large retrusive movements of the mandible after IVRO surgery are caused by lengthening of the pterygo-masseteric sling. This pattern is also characterized by an increase in the lower anterior face height and an improvement in the angle of convexity. The findings of the present study show that during the postoperative period there was a trend for posterior (clockwise) rotation of mandibular plane ($P < .05$) in the IVRO group. This pattern was characterized by a decrease of the convexity angle ($P < .001$) and facial plane angle ($P < .05$) as well as an increase in the gonial angle ($P > .05$). These changes made the hard tissue profile of the IVROs less concave.

The main disadvantages of the IVRO procedures were condylar sag, necrosis of the distal tip of the proximal segment, and the need for postoperative MMF.[7,16] The joint space was intentionally increased with inferior and anterior condylar position after IVRO surgery when most of the medial pterygoid muscle is stripped from the proximal segment to improve the disc-condyle relationship. This varied by the amount of medial pterygoid muscle detached from the proximal segment.[1,4,17]

Soft Tissue

There are many studies utilizing soft tissue analysis as a guide for orthognathic treatment.[18–20] A purpose of orthognathic treatment is to achieve a harmonious skeletal, dental, and soft-tissue relationship for the improvement of facial esthetics and function.[21]

It is so meaningful to include soft tissue evaluation for the treatment program and the therapeutic prediction. Alterations of the soft tissue profile that accompany mandibular setback surgery have been introduced by several studies.[22,23] However, the prediction after orthognathic surgery remains a problem because of variability of the soft tissue and the differences in

Table 3. Comparison between Horizontal and Vertical Changes (mm) of Hard Tissue Landmarks After Surgery (T3-T2)

	SSRO[a] T3-T2			IVRO[a] T3-T2				
Landmark	Mean	SD		Mean	SD		Difference (P)	
Horizontal								
U1	0.89	1.67	**	−0.40	1.82	NS	.00838	##
L1	1.14	1.78	**	−0.67	1.61	*	.00044	###
B Point	0.74	2.00	*	−2.15	2.47	***	.00004	###
Pg	1.08	1.98	**	−2.95	3.46	***	.00001	###
Me	0.71	3.24	NS	−3.14	3.52	***	.00021	###
Go	−1.42	3.32	*	2.07	3.09	**	.00035	###
Vertical								
U1	0.78	1.40	**	−0.17	1.69	NS	.0222	#
L1	1.27	1.51	***	0.84	1.65	*	.18315	NS
B Point	−0.19	1.57	NS	0.80	2.06	*	.03765	#
Pg	0.37	1.70	NS	0.79	2.11	*	.23184	NS
Me	0.75	1.77	*	1.77	1.79	***	.03056	#
Go	7.13	3.61	***	2.81	3.97	**	.00021	###

[a] SSRO indicates sagittal split ramus osteotomy; IVRO, intraoral vertical ramus osteotomy. SD indicates standard deviation; NS, not significant.

* Indicates significant changes between T3-T2. * $P = .05$; ** $P = .01$; *** $P = .001$.

# Indicates significant difference between SSRO and IVRO groups. # $P = .05$; ## $P = .01$; ### $P = .001$.

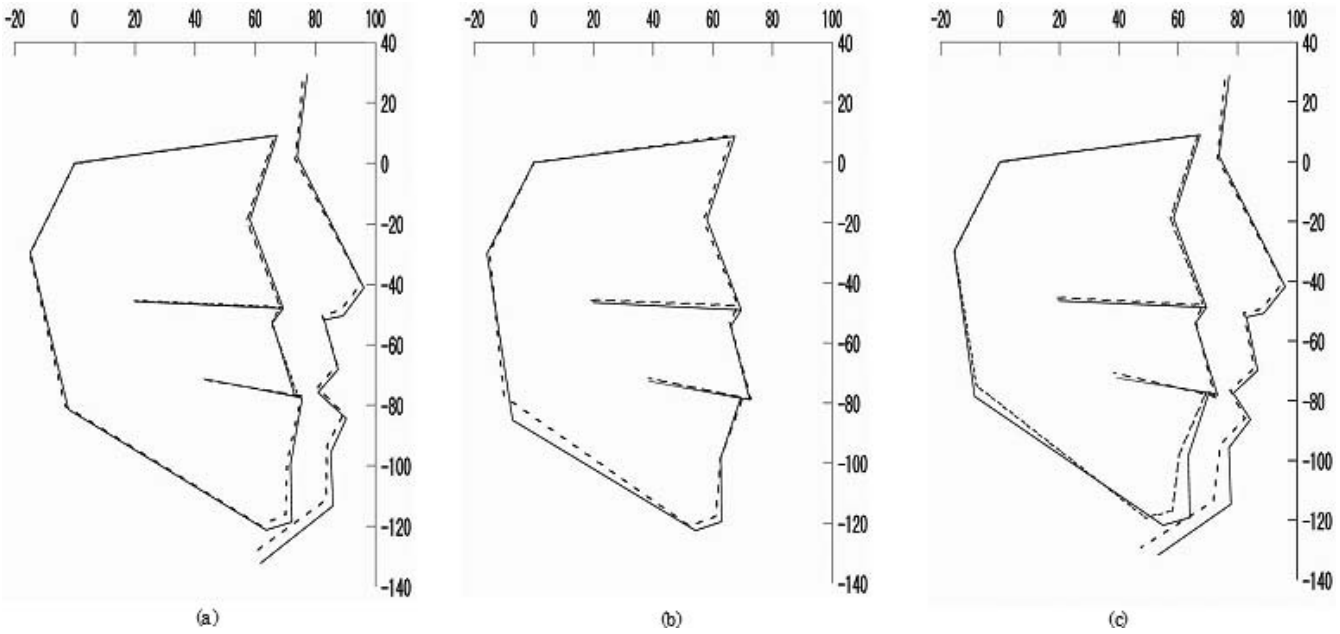

Figure 3. Superposition of profile diagrams of SSRO (black line) and IVRO (dotted line) groups. (a) Start of preoperative orthodontic treatment (T1). (b) Immediately after surgery (T2). (c) Completion of postoperative orthodontic treatment.

soft tissue displacement compared with mandible displacement.[18,24] Mobarak et al[10] pointed out that the changes in the soft tissue profile following setbacks in women demonstrated greater soft tissue movement in response to skeletal repositioning compared with men (statistically significant for the upper lip and chin; $P < .05$). In the present study, the mandible rotated posteriorly after setback surgery in the IVRO group. Consequently, the soft tissue mental region was located backward. These changes occurred at the postoperative stage so that the soft tissue profile became less prognathic.

Though a profile with a more retruded mandibular position is perceived as attractive in young Japanese women,[25] the excessive backward positioning of the soft tissue pogonion may result in spoiling the esthetic evaluation of the whole orthognathic treatment. Since facial attractiveness is an important physical attribute with perceived personality traits and social ability, it is important to predict such rotations in the postoperative period.

CONCLUSIONS

- Though IVRO procedures have been thought to be favorable to the TMJ because of anterior-inferior repositioning of the condyle, a tendency for remarkable changes in the IVRO group were seen in the backward rotation with point B, Pg, and Me after release of maxillomandibular fixation in comparison with the SSRO group.
- The soft tissue profile of IVRO group especially showed a retromandible after completion of postoperative orthodontic treatment in comparison with the SSRO group.

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