# Changes in occlusal force after mandibular ramus osteotomy with and without Le Fort I osteotomy

**Changes in occlusal force after mandibular ramus osteotomy with and without Le Fort I osteotomy**

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**Abstract**

The purpose of this study was to evaluate the differences in bite force changes and occlusal contacts after sagittal split ramus osteotomy (SSRO) and intraoral vertical ramus osteotomy (IVRO) with and without Le Fort I osteotomy.

The subjects were 60 women patients with diagnosed mandibular prognathism with or without asymmetry; these patients were divided into 4 groups (SSRO, IVRO, SSRO with Le Fort I osteotomy and IVRO with Le Fort I osteotomy). Bite force and occlusal contacts were measured preoperatively and at 1, 3, 6, and 12 months after surgery with pressure-sensitive sheets. The difference among surgical procedures was examined statistically.

Maximum bite force and occlusal contacts returned to the preoperative levels between 3 and 6 months. Regarding time-dependent changes in bite force and occlusal contact area, there were no significant differences among the groups.

In conclusion, this study suggested that the combination of IVRO or SSRO and Le Fort I osteotomy did not affect postoperative time-dependent changes.

Orthognathic surgery can alter not only morphological aspects, but also functional aspects. One of the major objectives of orthognathic surgery is to improve bite force. Many studies have been published regarding occlusal force after orthognathic surgery.[3,6,7,9,11-14] Recently, a pressure-sensitive system (Dental Prescale pressure-sensitive sheets and the Occluzar analyzer of these sheets) has been developed by Fuji Photo Film Company and several studies have been conducted with this system.[3,8,9,11] However, these studies described only the change in occlusal force before and after sagittal split ramus osteotomy (SSRO).[2,15] The SSRO has become one of the preferred surgical procedures for the correction of various jaw deformities. However, its alternative, the intraoral vertical ramus osteotomy (IVRO), has also become a common procedure.[1] In the correction of mandibular prognathism, SSRO with rigid fixation has several advantages over the IVRO with maxillo-mandibular fixation (MMF), such as a larger bony interface between the segments, easier fixation, and earlier healing as a result. Therefore, the SSRO can provide immediate postoperative jaw mobilization without MMF. Furthermore, Le Fort I osteotomy is also used very frequently with SSRO or IVRO for orthognathic surgery,[10] although the purpose for applying this procedure varies.

When surgical procedure was determined, the recovery of function such as occlusal force is one of the important factors to select the surgical procedure.Although it is very important and helpful to know the recovery of the occlusal force after different orthognathic procedures, it is unclear whether surgical procedure affects the recovery of occlusal force.

The purpose of this study was to evaluate the differences in bite force changes and

occlusal contacts after SSRO and IVRO with and without Le Fort I osteotomy.

**Patients and Methods**

The retrospective study comprised 60 women patients (mean age, 23.2 years and range, 15-36 years and standard deviation, 6.0 years). Their conditions were diagnosed as mandibular prognathism, mandibular prognathism with mandibular asymmetry, and mandibular prognathism with bimaxillary asymmetry. The subjects were divided into 4 groups. Surgical procedure was determined after patients' informed consent was obtained. Group 1 consisted of 15 women who underwent bilateral SSRO (by the Obwegeser, Dal-Pont or Obwegeser method) with rigid fixation using mini-plates and monocortical screws. Group 2 consisted of 15 women who underwent IVRO without segmental fixation. Group 3 consisted of 15 women who underwent SSRO and Le Fort I osteotomy. Group 4 consisted of 15 women who underwent IVRO and Le Fort I osteotomy. All patients who underwent SSRO alone and SSRO with Le Fort I osteotomy received MMF with IMF screws (Stryker LEIBINGER, Freiburg, Germany) at the area of the anterior teeth for approximately 1 week and sequential elastic traction to maintain the ideal occlusion. All patients who underwent IVRO and IVRO with Le Fort I osteotomy received MMF with IMF screws at the area of the anterior teeth for approximately 2-3 weeks and sequential elastic traction to maintain the ideal occlusion. All patients received orthodontic treatment before and after surgery.

**Measurements**

A pressure-sensitive system was used in this study. This system consists of a

pressure-sensitive sheet (Dental Prescale; Fuji Photo Film Co., Tokyo, Japan) and its analyzing apparatus (Dental Occlusion Pressuregraph FPD-705; Fuji Photo Film Co.) that was connected with a personal computer (LaVieC, LC50H/3, NEC, Tokyo Japan) (Fig.1). Data on the reproducibility and the method of calibration has been reported.[3,4,8,9] Each patient was seated with his or her head in an unsupported natural position, looking forward. We ensured the Frankfort horizontal (FH) plane was approximately parallel to the floor. The pressure-sensitive sheet was placed between the maxillary and mandibular teeth and the patient was instructed to bite as forcefully as possible for about 3 seconds. The sheet was read and analyzed by the Dental Occlusion Pressuregraph and the results were put into the computer and visualized on the display screen. The patients' bite forces were measured just before the operation and at 1 month, 3 months, 6 months, and 1 year after the operation.

**Statistical analysis**

Data of bite force and occlusal contact were statistically analyzed with Stat View™ version 4.5 software (ABACUS Concepts, Inc., Berkeley, CA, USA). Difference between groups was analyzed by multiple comparisons using the Scheffe's F test. Time-dependent changes were examined by analysis of variance (repeated measure ANOVA).

**Results**

In all groups, bite force and occlusal contact area were the lowest at 1 month after surgery. However, they increased to the preoperative levels between 3 and 6months after surgery (Figs 2 and 3, Table1).

Regarding bite force changes among 4 groups, no significant differences were found preoperatively. Significant differences were found between Group1 and Group2 (P=0.0034) and between Group2 and Group3 (P=0.0084) 1 month after surgery. However, 3 and 6 months after surgery, there were no significant differences among all groups. 1 year after surgery, Group2 significantly showed greater value than Group1 (P=0.0442), Group2 (P=0.0121) and Group4 (P=0.0456).

Regarding occlusal contact area changes, Group2 was greater than Group1 preoperatively (P=0.0333), although there were no significant differences between other groups. Group2 significantly showed greater value than Group1 (P=0.0040) and Group3 (P=0.0209) 1 month after surgery. Group2 was significantly grater than Group3 (P=0.0436) and Group4 (P=0.0380) 6 months after surgery. 1 year after surgery, Group2 also showed greater value than Group1 (P=0.0275), Group3 (P=0.0081) and Group4 (P=0.0144).

Regarding the time-dependent changes in bite force and occlusal contact area, no significant differences were found among the groups, however, the time-dependent changes within subjects in all groups showed significant differences with ANOVA (Table 2).

**Discussion**

Several devices for occlusal analysis have been developed. The T-scan system developed by Maness et al. measures bite force and the distribution of occlusal contacts.[8] However, this system occasionally misreads the occlusal contact area. In 1977, a pressure-sensitive sheet was developed for industrial examination by Fuji

Photo Film Company. In 1978, Hirasawa et al. reported that the pressure-sensitive sheet was useful for measuring bite pressure and occlusal balance.[5] Bite force, occlusal contact area, and occlusal balance are measured and analyzed using the pressure-sensitive sheet and its analysis apparatus (Occluzer, Fuji Photo Film Company). The sheet of this system is very thin and flexible, and its measured values are unaffected by velocity, duration of pressure, or temperature. Thus, this device was considered to be more useful and reliable than other devices. Regarding to the reproducibility of data, Hattori et al. evaluated the reliability of this device for occlusal force measurement, both on a subject and on casts. They reported the linear relationship between the applied and measured loads. They calculated occlusal force during maximum voluntary clenching of the subject was 8 to 60 N at premolars and 63 to 330 N at molars.[4] Several studies have used the pressure-sensitive sheet to report the results after sagittal split ramus osteotomy. Harada et al. reported that both bite force and occlusal contact area were the lowest 2 weeks after surgery and recovered to the preoperative level between 8 weeks and 3 months, then they increases and exceeded the preoperative level at 6 months after surgery.[3] Nagai et al. reported that the occlusal contact area and bite force of patients 1 month after the operation had decreased to below preoperative value, these values 12 months after the operation had increased by 2.0 and 1.8 times in women compared with preoperative values.[9] However, the differences among orthognathic surgery procedures have not been examined with the pressure-sensitive sheet.

Throckmorton et al. used a bite force transducer set for a 15-mm bite rise and compared the differences between setback surgery involving vertical ramus osteotomy

and advancement surgery.[13] However, none of the differences were statistically significant. Kim and Oh have stated that a comparison between surgical procedures showed a shorter recovery time and more rapid improvement for the SSRO group than for the extraoral vertical ramus osteotomy (EVRO) group, although different devices were used to measure bite force.[7] Furthermore, the duration of maxillo-mandibular fixation (MMF) also may have had a significant effect on muscular rehabilitation.[2]

In our study, occlusal force and occlusal contact area in IVRO group showed a tendency to be greater than other groups from pre-operation to 1year after surgery. However, in the time-dependent changes with ANOVA, there were no significant differences between other groups so that IVRO could be not more rapid than other groups in recovery in bite force and contact area.

Whether the major influencing factor affecting the recovery of maximum bite force was the surgical method or the duration of MMF was unclear. In our study, MMF duration had been determined to be approximately 2-3 weeks for the IVRO with and without Le Fort I groups and approximately 1 week for the SSRO with and without Le Fort I groups. After the removal of MMF, maxillo-mandibular traction was usually performed with elastic to maintain the close occlusion relationship. However, these periods were not similar in each patient. Therefore, we should consider that every procedure group would receive a comprehensive series of treatments including MMF duration, maxillo-mandibular traction, and pre- and postoperative orthodontic treatment.

Proffit et al. have stated that the bite force is primarily affected by two factors: the amount of force generated by the masticatory muscles and the length of their moment

arms.[12] Throckmorton et al. proposed that the surgically altered geometry might influence the maximum bite force directly by altering the mechanical advantage of individual muscles.[14] They noted that mandibular setback surgery generally increased the mechanical advantage, whereas advancement surgery decreased it. However, they found in another investigation that the bite forces in the mandibular setback group were smaller than those in the mandibular advancement group postoperatively. As one explanation for this finding, the authors suggested that the surgically induced changes in mechanical advantage were so small that they failed to affect the bite force.

Throckmorton et al. concluded that any differences between the types of surgery were substantially smaller than the differences between male and female patients.[13] In our study, subjects were all women so that a factor due to sex-related difference could be excluded.

Several other factors are thought to affect the bite force after orthognathic surgery: changes in the muscles themselves, occlusal contacts, and temporomandibular joints. However, a strongly positive correlation between bite force and occlusal contact have been obtained in investigations using the pressure-sensitive sheet system and the T-scan system.[3,6,9,11] In our study, occlusal force might show similar time-dependent change to occlusal contact area, from these reasons.

In conclusion, this study suggested that the difference in surgical procedure did not significantly affect the postoperative time-dependent changes in bite force and occlusal contacts.

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Legend

Fig. 1. Pressure-sensitive system, A) pressure-sensitive sheet (Dental Prescale; Fuji Photo Film Co., Tokyo, Japan), B) analyzing apparatus (Dental Occlusion Pressuregraph FPD-705; Fuji Photo Film Co.), C) the result on computer display

Fig. 2. The change in bite force

Error bars show standard deviation.

Fig. 3. The change in contact area

Error bars show standard deviation.

Table 1. Changes in bite force (Newtons) and occlusal contact area (mm2)

* shows significant difference with Scheffe's F test at $P<0.05$.

SD, shows standard deviation.

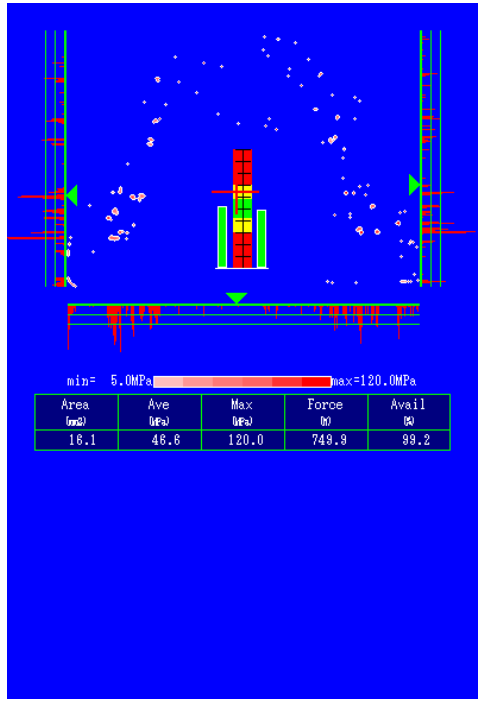
Table 2. The results of comparisons between time-course changes in 2 groups with repeated measure ANOVA

Group1: SSRO, Group2: IVRO, Group3: SSRO and Le Fort I, Group4: IVRO and Le Fort I

Fig. 1.


NAME
FUJIFILM
DENTAL
PRESCALE
50H R-L


OCCLUZER
PRESSUREGRAPH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max=120.0MPa
Area
Ave
Max
Force
Avail
16.1
46.6
120.0
749.9
99.2

A B C

Fig. 2.

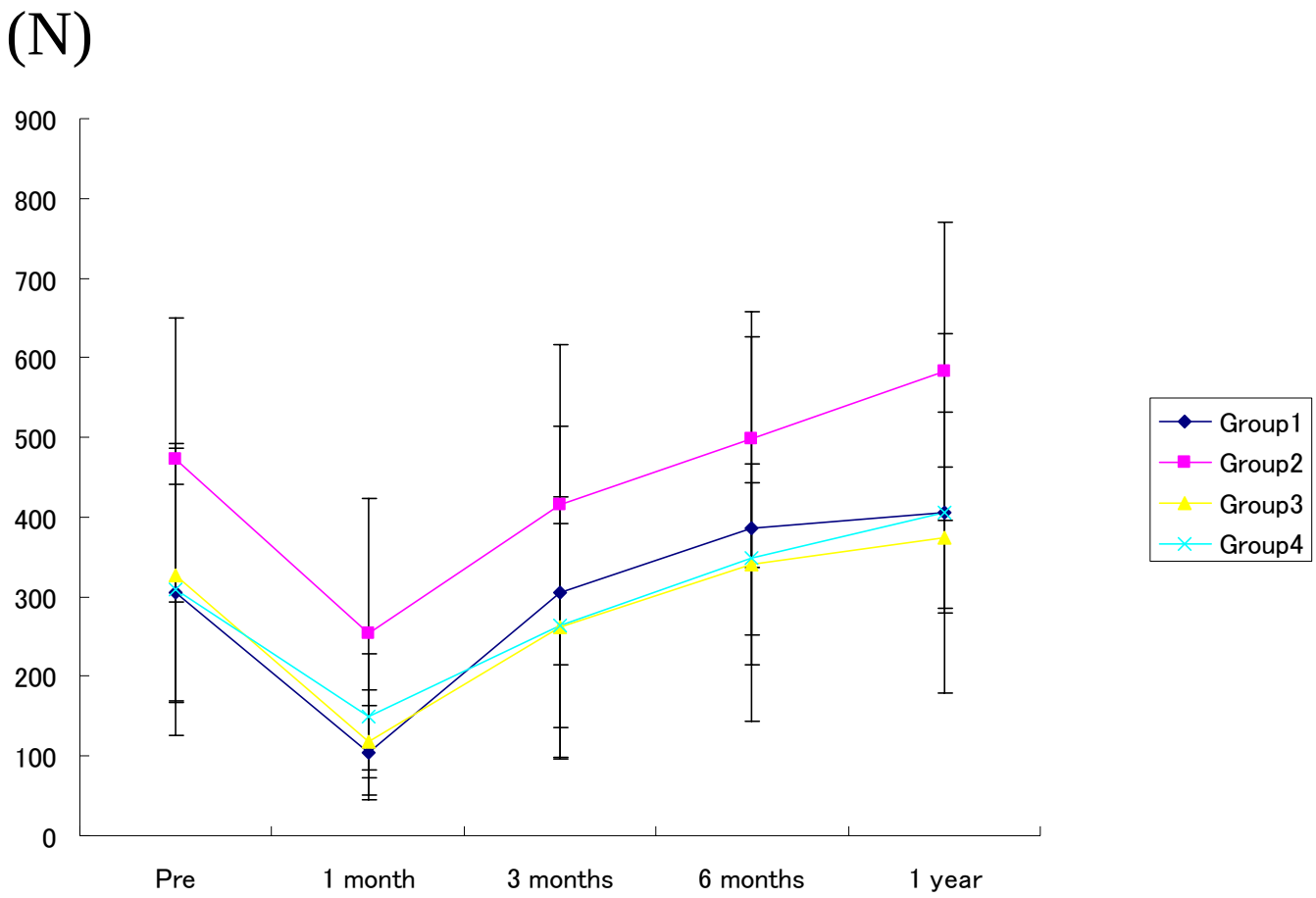
(N)
900
800
700
600
500
400
300
200
100
0
Pre
1 month
3 months
6 months
1 year
Group1
Group2
Group3
Group4

Fig. 3.

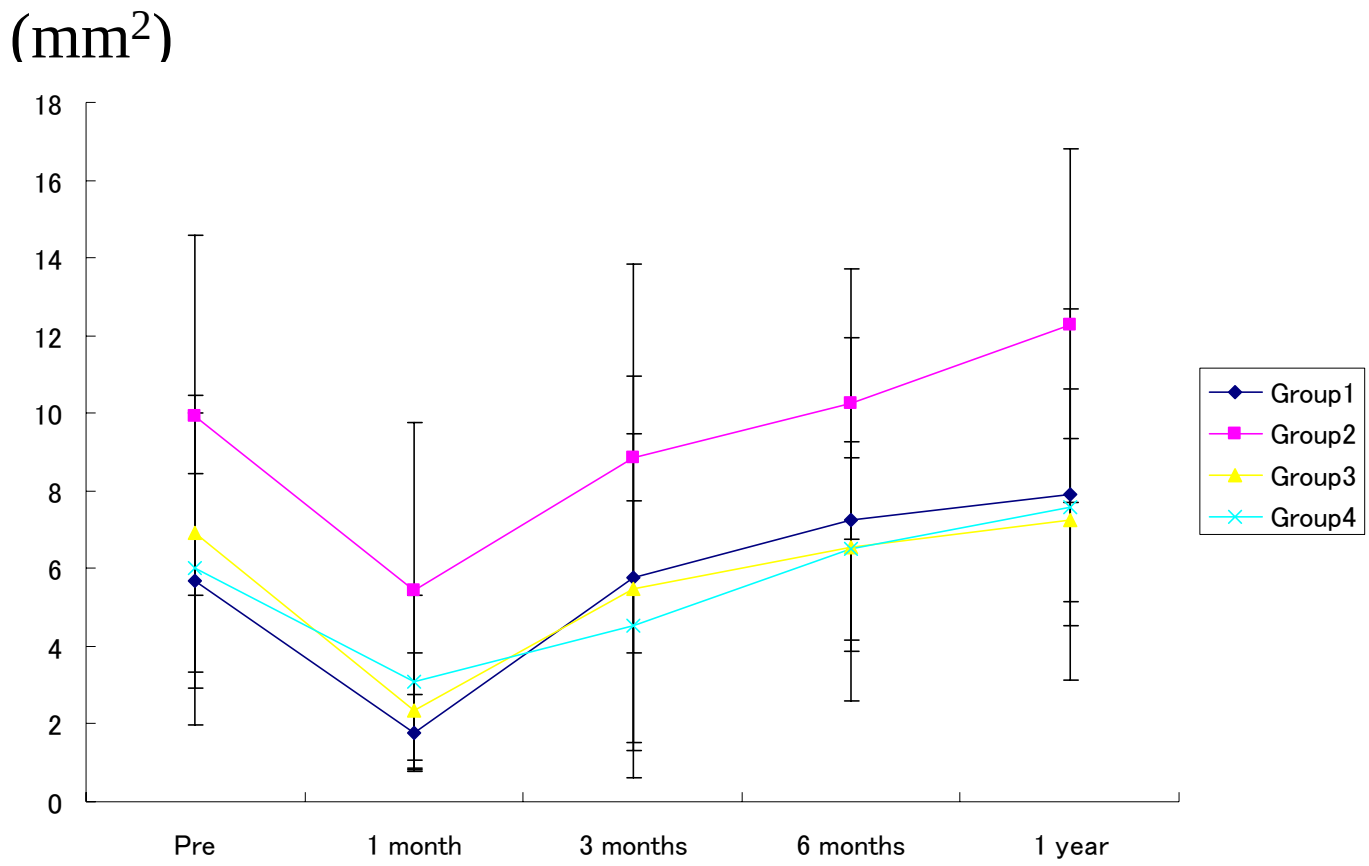
(mm2)
18
16
14
12
10
8
6
4
2
0
Pre
1 month
3 months
6 months
1 year
Group1
Group2
Group3
Group4

Table 1.

| Occlusal force (N) | Pre | | 1 month | | 3 months | | 6 months | | 1 year | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Average | SD | Average | SD | Average | SD | Average | SD | Average | SD |
| Group1 | 305.8 | 135.7 | 105.1 * | 59.0 | 305.0 | 209.1 | 385.8 | 241.4 | 405.2 * | 225.7 |
| Group2 | 471.8 | 179.0 | 253.2 * | 170.3 | 415.0 | 200.6 | 497.6 | 160.1 | 582.7 | 186.9 |
| Group3 | 327.4 | 159.8 | 117.3 * | 65.6 | 262.0 | 163.1 | 340.7 | 126.0 | 373.7 | 88.8 |
| Group4 | 309.3 | 183.8 | 150.7 | 78.5 | 263.6 | 128.6 | 348.0 | 95.9 | 406.1 | 125.7 |

| Contact area ($mm^2$) | Pre | | 1 month | | 3 months | | 6 months | | 1 year | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Average | SD | Average | SD | Average | SD | Average | SD | Average | SD |
| Group1 | 5.7 * | 2.8 | 1.8 * | 1.0 | 5.8 | 5.2 | 7.3 | 4.7 | 7.9 * | 4.8 |
| Group2 | 9.9 | 4.6 | 5.4 * | 4.3 | 8.8 | 5.0 | 10.2 * | 3.5 | 12.3 | 4.6 |
| Group3 | 6.9 | 3.6 | 2.3 | 1.5 | 5.5 | 4.0 | 6.6 | 2.7 | 7.3 | 2.1 |
| Group4 | 6.0 | 4.0 | 3.1 | 2.2 | 4.5 | 3.2 | 6.5 | 2.3 | 7.6 | 3.1 |

Table 2.

| Bite force | within subject | | | between subject | | |
|---|---|---|---|---|---|---|
| | df | F-value | P-value | df | F-value | P-value |
| Group1 vs Group2 | 1 | 19.48 | <0.001 | 4 | 0.32 | 0.86 |
| Group1 vs Group3 | 1 | 19.85 | <0.001 | 4 | 0.42 | 0.80 |
| Group1 vs Group4 | 1 | 18.38 | <0.001 | 4 | 0.51 | 0.73 |
| Group2 vs Group3 | 1 | 24.22 | <0.001 | 4 | 0.40 | 0.81 |
| Group2 vs Group4 | 1 | 22.58 | <0.001 | 4 | 0.37 | 0.83 |
| Group3 vs Group4 | 1 | 24.32 | <0.001 | 4 | 0.30 | 0.88 |

| Occlusal contact | within subject | | | between subject | | |
|---|---|---|---|---|---|---|
| | df | F-value | P-value | df | F-value | P-value |
| Group1 vs Group2 | 1 | 15.13 | <0.001 | 4 | 0.26 | 0.90 |
| Group1 vs Group3 | 1 | 15.55 | <0.001 | 4 | 0.58 | 0.68 |
| Group1 vs Group4 | 1 | 14.00 | <0.001 | 4 | 0.83 | 0.51 |
| Group2 vs Group3 | 1 | 17.45 | <0.001 | 4 | 0.56 | 0.69 |
| Group2 vs Group4 | 1 | 15.98 | <0.001 | 4 | 0.70 | 0.59 |
| Group3 vs Group4 | 1 | 17.71 | <0.001 | 4 | 0.71 | 0.59 |