Post-operative Stability After Bimaxillary Surgery in Patients with Facial Asymmetry: Comparison of Differences Among Different Original Skeletal Class Patterns

Kazuhiro Matsushita · Nobuo Inoue ·
Hiro-o Yamaguchi · Tadashi Mikoya ·
Kanchu Tei

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Abstract

Purpose When improving jaw deformity by two-jaw surgery, we are of the opinion from our clinical experience that a certain degree of undercorrection is occasionally beneficial from the perspective of stability. Functional deterioration is not always seen with undercorrection. We conducted this retrospective study to assess post-operative stability in patients with facial asymmetry, with the aim of both clarifying differences between the original three skeletal class patterns, and confirming the efficacy of surgery performed on the basis of our concept.

Patients and Methods All patients received optimal orthognathic treatment before and after surgery. Surgery was performed by our concept that undercorrection is not always bad. Nineteen patients were enrolled, and separated into three skeletal classes according to the ANB angle, because of the difference of the treatment modalities between them. Evaluations were performed by cephalometric measurements taken at least two-year post-operatively. Transverse occlusal cant, chin deviation, point A, point B, overjet and overbite were assessed.

Results In all patients, transverse occlusal cant improved to $<4^\circ$, which has been reported as the threshold for visual recognition of facial symmetry. Chin deviation was also

improved to the degree at which soft tissue can sufficiently mask the asymmetry. The changes remained stable throughout follow-up and satisfaction was obtained from all patients. **Conclusions** Irrespective of original skeletal class patterns, post-operative stability of patients with facial asymmetry was achieved. Undercorrection is thus by no means problematic from the clinical perspective of stability and our concept of approach appears valid.

Keywords Asymmetry · Stability · Undercorrection · Two-jaw surgery

Introduction

Transverse occlusal cant is frequently seen in patients with facial asymmetry, accompanying lateral deviation of the mandible. To improve the current status and obtain desirable occlusion, two-jaw surgery is often performed [1]. Differing from cases requiring simple improvement of hypognathia or hypergnathia, careful attention should be paid to relapse due to the deficiency of bone contact at the osteotomy line and changes of muscle configuration, resulting from rotational movement of the osteotomized segment in the coronal and axial planes. As for the maxilla, achieving horizontal leveling of the maxillary occlusal plane can be performed by extrusion of the shorter side and intrusion of the longer side, with this maneuver creating a bone gap or step at the osteotomy line on the extrusion side. Although interpositional or onlay bone grafting is generally performed, the bone is resorbed over time, and the forces produced by the surrounding original soft tissue components and post-operative scar formation, and the patient's individual masticatory pattern accelerates bone resorption in some cases. Under these conditions, the improved state immediately after surgery is

K. Matsushita (✉) · N. Inoue · H. Yamaguchi · K. Tei
Division of Oral Pathobiological Science, Department of Oral
and Maxillofacial Surgery, Graduate School of Dental Medicine,
Hokkaido University, N13 W7, Kita-ku, Sapporo,
Hokkaido 060-8586, Japan
e-mail: matsushi@den.hokudai.ac.jp

T. Mikoya
Stomatognathic Function, Center for Advanced Oral Medicine,
Hokkaido University Hospital, N13 W7, Kita-ku, Sapporo,
Hokkaido 060-8586, Japan

no longer expected to remain stable. As for the mandible, an osteotomized distal segment will sometimes interfere at the superior or posterior edge against the inner surface of the proximal segment when rotating in the coronal or axial plane. The greater the degree of rotation, the more severe the interference. Even if the occlusal cant itself can be improved by the surgery, the original unique structure of the bone and masticatory musculature remains unchanged and the muscles will be stretched on one side and relaxed on the other side with rotational movement of the distal segment, with even more complicated results from movement in three dimensions. Distortion will also arise. The forces evoked by stretched and distorted muscles will thus pull the segment back toward the original position. To compensate for such relapse, overcorrection is often employed. However, we believe that this overcorrection makes the gap wider at the osteotomy site and exacerbates the stretching of not only the masticatory muscles, but also the suprahyoid muscles, with these factors exerting greater force for the osteotomized jaw to move back toward the original position, sooner or later resulting in relapse. In addition, in this situation, the superior or posterior part of the mandibular distal segment will experience interference from the facing proximal segment much more frequently and the proximal segment will often be pushed out laterally much more strongly. The condyle will be displaced if the gap created at the anterior region of the proximal segment is closed forcefully. Overcorrection represents a very similar situation to using a high degree of movement for severe cant. Sometimes the greater the degree of improvement received, the greater the degree of relapse. Overcorrection for cases with severe cant just begins a vicious circle. Relapse of the maxilla and mandible are closely related to each other through interdigitation.

We have therefore been of the opinion that undercorrection is more beneficial than overcorrection, with rigid plating of the osteotomized segments at surgery and careful elastic traction post-operatively. This approach is based on our concept that the success of jaw deformity treatment should be judged not only by how much improvement can be achieved, but also by how long the post-operative state remains. To evaluate and compare differences in post-operative stability between the 3 different original skeletal class patterns because of the difference of the treatment modalities between them, we performed a longitudinal study of patients with facial asymmetry who could be followed for more than 2 years post-operatively with serial cephalograms.

Patients and Methods

Subjects

Study samples were collected from consecutive cases of completed orthognathic and orthodontic treatment

performed between 2005 and 2009 at Hokkaido University Hospital, Japan. Due to the retrospective nature of this study, it was granted an exemption in writing by the Medical Ethics Committee of Hokkaido University. This study was performed in conformity with the Declaration of Helsinki. Of all 64 patients who underwent two-jaw surgery in that period, 16 women and 3 men (mean age 28.9 years; range 18–40 years) met the following criteria, (1) facial symmetry diagnosed by the agreement of the majority at conferences on jaw deformity in the university hospital, by physical examination in the outpatient ward, evaluation of facial measurements, working dental casts, cephalometric analysis, and computed tomography, (2) completion of orthognathic surgery and orthodontic treatment, (3) complete records of cephalograms and facial photographs before and after treatment and (4) long-term follow-up <2 years after surgery. Patients with craniofacial deformities such as hemifacial microsomia and ones with post-traumatic asymmetry were excluded. Thirteen patients were followed up for more than 3 years after surgery, remaining 6 patients were for 2 years. Then, we evaluated the changes of each measurement up to 3 years after surgery; mean and standard deviation (SD) 3 years after surgery was calculated by the actual data present. Cases were divided into three groups according to the kinds of skeletal pattern. Skeletal class I, II and III were defined by ANB angles of between -1.0 SD and $+1.0$ SD, over $+1.0$ SD, and under -1.0 SD, respectively. Our treatment purpose and procedures were not aimed at esthetic improvement, but rather at good occlusion and functional improvement.

Presurgical Orthodontics and Followed by Surgery Plan

All patients received optimal pre-operative orthodontic treatment before orthognathic surgery. Leveling and alignment, space consolidation, and general coordination of both arches were performed. Patients were evaluated using facial measurements, working dental casts, and cephalometric analysis.

Desirable occlusion was planned using dental cast models. If the alveolar arch was narrow and/or inclination of the incisors could not be properly corrected by orthodontic treatment, maxillary separation into two or three segments was planned. After constructing the desirable occlusion, we then considered the most desirable position for the maxilla–mandibular complex. The vertical position of the upper incisors was determined by the expected amount of visible incisors. The sagittal position of the incisors was decided by sagittal maxillary positioning and incisor inclination. The vertical position of the maxillary first molars was determined by facial height, degree of rotation of the maxilla–mandibular complex and the amount of gap or step created by the maxillary movement at the osteotomy line.

Fig. 1 For post-operative stability of the mandible, we have long used two plates to stabilize the osteotomized segments on each side of the mandible. On the maxilla, plates were placed at the infra-zygomatic crest and at the piriform aperture in a conventional manner

Two-jaw surgery was conducted using a double-splint technique with some original modification of our own. The osteotomized maxilla was fixed with four titanium miniplates or a combination of two titanium miniplates at the infra-zygomatic crest and two bioabsorbable miniplates at the piriform aperture. Bone grafting was conducted on demand. For the mandible, sagittal split ramus osteotomy (SSRO) was performed and two titanium miniplates were used for fixation on each side in our original configuration: a straight plate was placed over the vertical osteotomy line at the buccal surface of the first molar and an L-shaped plate was placed at the distal or lateral part of the last molar over the osteotomy line, just crossing over the upper-lateral edge of the buccal shelf, to prevent the tail of the distal segment from moving upward or downward [2] (Fig. 1). Post-operative orthodontic treatment was performed for another 2 years on average. Titanium miniplates were removed in all cases 1–2 years after osteotomy and additional osseous genioplasty was also performed in cases with remaining excessive asymmetry or incompetent lip seal, comprising two cases each in skeletal class II and skeletal class III.

Measurements

Measurements were obtained by tracing serial lateral and frontal cephalograms (Fig. 2). Cephalography was performed at initial visit (T1), immediately before surgery (T2), immediately after surgery (T3), and 6 months (T4), 1 year (T5), 2 years (T6) and 3 years post-operatively (T7) with the teeth in occlusion and the lips in a relaxed position. All radiographs were traced by a single investigator on two separate occasions at least 1 month apart, so that cephalometric method errors were small and acceptable for the purposes of this study. All radiographs were magnified 110 % as per standard procedures. For frontal cephalometric analysis, Lo points were defined bilaterally as the

intersection of the oblique orbital line with the lateral contour of the right or left orbit and the connection of bilateral Lo points was defined by a horizontal reference line (orbital line). The perpendicular bisector of the orbital line was defined as the vertical reference line (mid-sagittal line). The transverse occlusal plane was defined as the line connecting mesio-buccal cusps of upper 1st molar on both sides, and occlusal cant was defined as the angle between the occlusal plane and orbital line. Chin deviation was evaluated using the menton (Me). The amount of frontal occlusal cant, the distance of chin deviation, and the angle created by the mid-sagittal line and the line connecting Me and the lower central incisor contact point were measured. Vertical distances of the upper first molar to the orbital plane on the longer side (Ld) and shorter side (Sd) were also measured. Canting ratio was calculated using the following formula: canting ratio = $Sd/Ld \times 100$. A ratio of 100 indicated a perfectly level frontal occlusal plane. For lateral cephalometric analysis, the X axis was defined as 7° below the sella-nasion (SN) line. This line is a reproducible approximation of the Frankfort horizontal plate. The Y axis was defined as the line perpendicular to the X axis passing through the sella. Distances of points A and B to each reference line were also measured along with overbite and overjet.

Statistics

The Kruskal–Wallis analysis was applied to analyze differences among the three types of class patterns. Values of $p < 0.05$ were considered significant. Analyses were performed using SPSS version 20.0 statistical software (SPSS, Chicago, IL).

Results

Patient Characteristics and Course of Treatment

The 19 patients' original malocclusions with asymmetry presented three classifications (Table 1). Six patients showed skeletal class I malocclusion, seven patients showed skeletal class II, and six patients showed skeletal class III. No dominance of laterality was seen in any skeletal class.

Duration of pre-operative orthodontic treatment of dental arch leveling and coordination ranged from 15 to 26 months. Post-operative orthodontic work was performed to achieve maximum interdigitation and maintain post-operative stability.

All patients underwent two-jaw orthognathic surgery to correct facial asymmetry and transverse cant. Surgery conducted on the maxilla was Le Fort I osteotomy; seven

Fig. 2 Cephalometric measurements. Frontal and lateral view

Table 1 Sample distribution

Deformity	N	Male	Female	Age	Deviation side	
					Right	Left
Skeletal class I	6	2	4	24.8 ± 8.0	3	3
Skeletal class II	7	0	7	32.3 ± 8.0	3	4
Skeletal class III	6	1	5	29.0 ± 7.7	3	3
Total	19	3	16	28.9 ± 8.1	9	10

cases were separated into 2-piece segments to widen the base of the alveolar arch, and two cases were separated into 3-piece segments to improve the axis of frontal teeth in addition to adjusting the width. Surgery performed on the mandible consisted of bilateral SSRO in all cases.

Measurement of Frontal Cephalograms

Overall Changes in Transverse Occlusal Cant and Chin Deviation

Figures 3, 4, 5 demonstrate the longitudinal improvements in transverse occlusal cant and chin deviation in all cases. Maximum angle of transverse occlusal cant and length of chin deviation before treatment were 7° and 17 mm, respectively, improving to 3.6° and 10.7 mm at final follow-up (Fig. 3). Occlusal cant improved to <4°. Me moved nearer to the midline. Some cases with small occlusal cant, <4° at initial visit were included in this study because asymmetry was evident especially in the patient with unilateral corpus enlargement regardless of the occlusal cant and chin deviation. As for the longitudinal changes in

Fig. 3 Longitudinal changes in occlusal cant at each case

distance of chin deviation in each case (Fig. 4), maximum deviation immediately before osteotomy was 22 mm. Almost all cases improved to around 5 mm during follow-up, at which point asymmetry is indiscernible by visual judgment due to masking by overlying soft tissue. As for the changes in angle of chin deviation (Fig. 5), similar movement was observed to those of distance. Most cases improved to around 5° during follow-up. Improved status remained over the long term and no clear tendencies toward relapse were seen in any patient during follow-up. Patients with marked cant and mild lateral deviation of the chin, i.e., with chin deviation not corresponding to the degree of occlusal cant, showed light contralateral deviation of the chin after surgery, but remained stable.

Mean Changes in Transverse Occlusal Cant and Canting Ratio

Figure 6 demonstrates longitudinal mean changes in transverse occlusal cant and canting ratio as categorized by

Fig. 4 Longitudinal changes in distance of chin deviation in each case. In two cases, the chin was deviated to the contralateral side because the degree of facial asymmetry was not coincident with that of occlusal cant

Fig. 5 Longitudinal changes in angle of chin deviation in each case

original skeletal class. In every skeletal class, occlusal cant was improved and remained stable, with no apparent differences among groups at every point ($p > 0.05$). The ratio also improved up to, but slightly under, approximately 100, indicating undercorrection. The ratio remained almost unchanged during follow-up, with the exception of 1 case in skeletal class II.

Distance of Chin Deviation

The distance of Me to the mid-sagittal plane improved with surgery (Fig. 7). The situation was well maintained until completion of orthodontic treatment. No differences were evident among groups ($p > 0.05$).

Angle of Chin Deviation

Changes in the angle created by the line connecting the mid incisors and Me, and the mid-sagittal plane were similar to

those of the distance of chin deviation (Fig. 7). No differences were evident among groups ($p > 0.05$).

Changes in Points A and B

The mean value immediately after surgery was set at zero and the position of each point was determined relative to that baseline (Fig. 8). The chart shows the changes in absolute value.

Movement direction and amount of both the anterior maxilla (point A) and anterior mandible (point B) differed from case to case, as indicated by the wide SD. Post-operatively, dynamic changes were seen in point B compared to point A. Patients with a skeletal class I and III jaw relationship showed greater improvements in anterior-posterior direction and the range was almost same but in opposite direction. Although post-operative changes were seen in all skeletal classes, they were trivial and there were no significant differences between groups. Values remained stable during follow-up. No differences were evident among groups ($p > 0.05$).

Overbite and Overjet

Similar to point B above, the amount of improvement in overjet is almost same in skeletal class II and class III although that of original deviation was greater in class II than in class III. Irrespective of differences among the three original skeletal patterns, post-operatively both overbite and overjet were stable with almost the same SD. Values were maintained long-term during follow-up (Fig. 9). No differences were evident among groups ($p > 0.05$).

Photographs and Radiographs

Representative cases of each skeletal pattern are shown in Fig. 10, and measures in Table 2. In all skeletal patterns, asymmetry was improved remarkably and undercorrection was not discernible by visual judgment even if subtle asymmetry was seen in the radiograph. In the representative of skeletal class II, osseous genioplasty was performed for remaining excessive asymmetry. The range of movement of the genial segment is occasionally limited by the position and course of alveolar nerve, and undercorrection may be selected even in this portion as well.

Discussion

In terms of the evaluation of post-operative stability, we consider that there is little sense in merely comparing mean measurements at each point, because measurements exhibit longitudinal changes in each patient, beginning at various

Fig. 6 Occlusal cant and canting ratio on average in each original skeletal class classified by ANB angle. Canting ratio reflected the degree of cant. There was no significant difference between groups on both items ($p > 0.05$)

Fig. 7 Distance and degree of chin deviation on average in each original skeletal class. No difference was apparent between groups after surgery ($p > 0.05$)

values and ending at different ones. Improving these values toward a “normal” value should not always be the goal of treatment. Furthermore, every patient shows individual characteristics of deformity, habits and living circumstances. No two patients underwent the same therapy. We therefore regard mean values as a reference guide when planning, to avoid deviating too far from the normal range. The present findings clearly demonstrated changes in transverse cant in all cases, on the basis of the concept that what is most important is how long an improved status can be maintained. After demonstrating changes in all cases and confirming good stability first, means with SD of each skeletal class patterns were demonstrated second to show the features of each skeletal class at a glance. This order is helpful for understanding the features of each class out of the gross outlines. The mean graph separated by original skeletal class reflected the unique characteristics and stability of each class.

Particularly in skeletal class II patients, the mandible will tend to back toward the original position over time, appearing as changes in point B and overjet, but the present cases did not exhibit any such tendency. Considering changes <2 mm in linear measurement as a methodological error [3] and, from our clinical and analytical experience, changes $<1^\circ$ in angular measurement as the same, stability appears fine regardless of the original skeletal pattern. Satisfaction was obtained from all patients at least 2 years after surgery. No changes that could be called relapse were apparent. Although this period may seem short for the observation of patients with asymmetry, some authors have reported 1 year as ample time for any relapse to occur [4, 5]. Judging from these reports, our evaluation of follow-up for at least 2 years is meaningful and some cases of 5-year follow-up (data not shown) supported the results, confirming that post-operative stability was fine and our fundamental strategy for surgery was universal

Fig. 8 Horizontal and vertical distance of both points A and B on average in each original skeletal class. No difference between groups was apparent after surgery ($p > 0.05$). The value immediately after surgery was set to zero

Fig. 9 Proper overbite and overjet were obtained after surgery and were maintained long-term during follow-up. No difference was apparent between groups after surgery ($p > 0.05$)

regardless of skeletal pattern. Sample size is too small and we could not tell the good stability statistically, but could tell it clinically. We believe these favorable results come out from the following concept.

As long as functional improvement is accomplishable, a certain degree of undercorrection is rather acceptable than

that of overcorrection. In other words, we do not attempt to achieve complete symmetry at any cost, even considering the compensation of the relapse in the future, as no mandible is distortion-free in three dimensions, and no individual tooth has the same size, shape, and position as the contralateral version, suggesting that aiming for complete

Fig. 10 Images of representative cases, skeletal Class I, Class II and Class III at initial visit and final visit

Table 2 Changes of representative cases

Deformity	Cant (°)		Distance (mm)		Angle (°)	
	Initial	Final	Initial	Final	Initial	Final
Skeletal class I	6.7	1.8	16.3	8.5	14.6	7.4
Skeletal class II	7.0	3.0	8.8	2.2	5.0	2.7
Skeletal class III	3.2	0.3	15.5	4.3	17.0	4.6

Measurements of one representative case selected from each skeletal pattern are shown. Each case matched the one in Fig. 10

Cant transverse occlusal cant, *Distance* distance of chin deviation, *Angle* Angle of chin deviation

symmetry is essentially futile. Few people exhibit complete facial symmetry. Some reports have confirmed facial asymmetry as the rule rather than the exception [6], and asymmetry is an intrinsic characteristic of the human race [7]. Therefore, the operative risk is increased when aggressive treatment is attempted simply only for the sake of “improvement”, aimed only at achieving exact symmetry, and only poor fruit will be obtained in the end; both

patients and doctors will see no benefit from such surgery. We do not intend to leave asymmetry; rather, we dare not run the risk of pursuing symmetry as a goal in itself. The degree of symmetry worth achieving varies from case to case and firm indications are lacking. The purpose of our surgery is not merely to achieve a symmetrical face, but instead to improve the dysfunction of the oral region, concomitantly with a more balanced configuration of the face suitable for ordinary oral function. We think form follows function, as well. A mild level of asymmetry is thus tolerated, and success is judged based on the amelioration of oral function and the long-term avoidance of relapse. Present results reveal that postoperative stability was fine and facial asymmetry was not obviously seen at all. We never heard complaints. In Japan, national health insurance covers a part of medical cost even in the orthognathic field if the surgery is performed for the functional improvement under the diagnosis of jaw deformity. But it does not cover at all if it is for cosmetic purpose. National circumstances may also contribute to the attitude of surgeons and patients.

In more concrete terms, as for the occlusal cant correction of the maxilla, it can be achieved by extrusion of the shorter side and intrusion of the longer side in theory, then we consider how to make an osteotomy line to obtain bone contact as much as possible, and interpositional or onlay bone grafting are also selected aggressively if necessary. As for the cant correction of the mandible, although it can usually be controlled by surgery, but in some cases it cannot be controlled completely due to factors such as interference between the segments, and distortion of the unique structure of the original mandible. The proximal segment will often be extruded laterally by the posterior or superior edge of the distal segment. In this condition, the mandible angle will show prominent lateral deviation or the condyle will become displaced laterally pushing the anterior part of the proximal segment from the lateral side to make the gap small during fixation. We occasionally take into account an undercorrection as an option like placing the maxilla in a slightly inclined or deviated position where proximal and distal segments of the mandible align passively to each other in three-dimensions, not only coronally, but also axially and sagittally. Indeed, making a green stick fracture of distal segment of the mandible at the retromolar region should be an option as well [8]. We take these problems into consideration when making a surgical planning in each case under the concept of safe and surefire maneuver.

Clinically, mild deviation is masked by overlaying soft tissues. Cant does not always lead to visually apparent asymmetry, as long as the angle is within 4° [9]. Some patients have a tendency to compensate for their appearance by changing head posture relative to the ground [10]. Normal masticatory function is usually possible within this range. This magnitude of asymmetry probably does not have detrimental effects on post-operative outcome. Present results clearly showed it. Every patients improved to be within 4° of the cant and asymmetry is not obviously seen at all. No oral dysfunction was seen either. Lip canting also improved by surgery even though a small amount of bone deviation remained. If overcorrection is given, deviation will be much more prominent to the contralateral side and lip function will further deteriorate by distortion of the soft tissue exerted by bone movement. Taken together, maxillary cant correction should be performed within the range for which mandibular movement is reasonable, without harming bone union or surrounding soft tissue. Overcorrection is therefore not always beneficial, because greater stretching of soft tissue will result in greater retraction. Over movement will finally lead to over relapse. This axiom is often borne out in our clinical practice.

Finally, the imperative from the perspective of achieving long-term stability after improving laterality and asymmetry is to inform the patient of the mechanisms

involved, and why relapse occurs, to maintain the motivation to keep good occlusion. It is also essential to pay attention to keep centric occlusion with bilateral molars and avoid biting at the position where it was easy to masticate pre-operatively. During post-operative orthodontic treatment, the tooth contact positions at which you can bite easily and at which it is desirable from the point of orthodontic treatment are quite different. The role of intermaxillary elastic tissue is also a crucial and indispensable factor, particularly when improving laterality and asymmetry.

Although our notion seems to be a little bit eccentric, it is undeniably true and brings about a beneficial effect in clinical practice from our experience.

Conclusion

This retrospective study demonstrated that there was no difference in post-operative stability regardless of original skeletal class. Complete transverse occlusal cant correction was not achieved, but was $<4^\circ$, the level at which visual judgment can detect asymmetry. Satisfaction was obtained from all patients. We believe that this result was attributable to our concept. Complete horizontal leveling of the occlusal cant is not always achieved or even necessary for treating patients with facial asymmetry, because non-components of both sides are the same and problems secondary to making the plane horizontal will arise. In order to obtain postoperative long-term stability and fine results, reasonable bone positioning, rigid fixation and secure bone grafting at the osteotomy gap are more essential and important rather than merely trying to achieve symmetry.

Conflict of interest The authors declare that they have no conflict of interest.

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