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DOI: 10.2478/aoj-2003-0008

Original Article

# Stability of combined Le Fort I maxillary advancement and mandibular reduction

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*Background:* There have been reports that correction of severe Class III abnormality by single jaw surgery may invite relapse in the long-term. The purpose of this study was to retrospectively evaluate the stability of combined Le Fort I maxillary advancement and bilateral sagittal split osteotomies for mandibular reduction.
*Methods:* Thirty patients with a skeletal Class III malocclusion underwent bimaxillary surgery using rigid fixation and interpositional bone grafting of the maxilla. The average age was 24.4 years, and the mean follow-up period was 20 months (Range: 12–63 months). Post-operative changes were measured on lateral cephalometric radiographs using an anatomical best-fit technique.
*Results:* The maxilla was advanced, on average, 6.1 mm (SD: 1.8 mm) and repositioned superiorly at PNS 1.9 mm (SD: 2.1 mm). The mandible was repositioned posteriorly 5.6 mm (SD: 4.2 mm) at menton, which also auto-rotated superiorly. At follow-up, the maxilla relapsed horizontally 0.6 mm (SD: 1.1 mm, $p < 0.01$) with no significant vertical change. The maxillary central incisors were proclined and the interincisal angle was reduced. Menton relapsed anteriorly 1.4 mm (SD: 2.7 mm, $p < 0.01$), and gonion rotated superiorly 1.5 mm (SD: 2.3 mm, $p < 0.001$). In 67 per cent of cases menton moved anteriorly less than 2.5 mm. The overjet and overbite did not change significantly.
*Conclusions:* The data show that 12-months post-operatively, maxillary advancement combined with mandibular setback was relatively stable in the horizontal and vertical planes.
Aust Orthod J 2003; 19: 57–66

Received for publication: November 2002
Accepted: April 2003

## Introduction

Class III skeletal malocclusions are usually corrected with a combination of orthodontic treatment and orthognathic surgery to maximize facial aesthetics and to provide ideal occlusal results.[1,2] The correction of large Class III skeletal disproportion by single jaw surgery alone may invite relapse in the long-term and be detrimental to facial balance.

According to Bailey *et al.*[2] the number of patients undergoing bimaxillary surgery for the correction of Class III malocclusions has increased since 1985. However, only a few studies have investigated stability after combined maxillary and mandibular procedures using rigid fixation.[3–8] Earlier studies have reported variable results and mild to moderate relapse following bimaxillary surgery with intermaxillary fixation and/or transosseous wire fixation.[3–5,8,9] These studies were limited by small, heterogeneous samples, with a mixture of surgical procedures and techniques. Furthermore, in some studies the cephalometric reliability controls have been inadequately described. Profitt and co-workers[9] reviewed the stability of bimaxillary osteotomies in 51 Class III patients following wire and rigid fixation. They reported good post-operative stability of treated Class III long-face deformity, and moderate vertical relapse of the maxilla and anterior relapse of the mandible following maxillary down-graft advancement with mandibular setback. However, following maxillary advancement with no vertical alteration both the mandible and maxilla relapsed.[9] A recent study by Politi *et*

*al.*[3] analysed the stability of Class III malocclusions following bimaxillary surgery and compared the use of rigid and semi-rigid (wire) fixation combined with six weeks of intermaxillary fixation. In the rigid fixation group 90 per cent of the anteroposterior relapse occurred during the period of intermaxillary fixation. In contrast, most of the relapse in the semi-rigid group followed the release of the intermaxillary fixation. The relapse in each group was similar in the long-term.

The purpose of this retrospective study was to evaluate, in patients with Skeletal III malocclusions, the long-term stability following combined maxillary advancement and mandibular reduction using rigid fixation.

## Patients and methods

Cephalometric data were obtained from 30 patients (21 female, 9 male) with a Skeletal III malocclusion, who had a Le Fort I osteotomy for maxillary advancement and concomitant bilateral sagittal split osteotomy for mandibular reduction. Patients were included if they were diagnosed with anteroposterior maxillary hypoplasia and mandibular hyperplasia, with or without a degree of asymmetry. Patients were excluded from the study if they were still growing, had an associated cleft or craniofacial deformity, or had a genioplasty at the same time as the bimaxillary surgery. All patients had pre- and post-operative orthodontic treatment with fixed appliances in both arches. The mean age was 24.4 years (Range: 15–40 years), and the mean follow-up period was 20 months (Range: 12–63 months). The subjects were classified into three groups: Group A, total sample (N = 30); Group B, one-piece maxillary procedures (N = 18); Group C, segmental maxillary procedures (N = 12).

### *Surgical technique*

A standard Le Fort I maxillary down-fracture osteotomy was performed by the same surgeon. The maxilla was repositioned passively and stabilised using four titanium L-shaped mini-plates. In the segmental cases a U-shaped osteotomy of the palate was performed and a palatal splint wired *in situ*. In all cases, interpositional grafting of the anterior and lateral bony walls of the maxillae were performed using either block corticocancellous bone from the iliac crest or local bone fragments harvested from the operative sites, for smaller defects. Standard bilateral mandibular sagittal osteotomies were then performed, and the segments were stabilised bilaterally with three bicortical positional screws. Occlusal splints and wire intermaxillary fixation were not used post-operatively. Instead, "light" intermaxillary elastics were placed at the completion of the surgical procedures and maintained for approximately four weeks. In segmental cases, U-shaped palatal splints and a continuous rectangular orthodontic arch wire were inserted at the time of surgery to provide stability to the fragments. Palatal splints were removed eight weeks post-operatively.

### *Cephalometric analysis*

Lateral cephalometric radiographs were taken of each patient pre-operatively (T1), immediately post-operatively (T2), and at least 12 months post-operatively (T3). The anterior cranial fossa and cranial base triangle (basion-sella-nasion)[10,11] on each radiograph were traced on acetate paper. A palatal template was used to locate PNS, ANS and point A[12] and a mandibular template was used to locate point B, pogonion, menton and the inner cortex of the anterior part of the mandible.[10,13] Each tracing was then superimposed on the T2 and T3 radiographs using the anterior cranial fossa and cranial base triangle, and the landmarks located in sequence with the aid of the templates. The tracings were digitised, measured and analysed using Quick Ceph Image software (Quick Ceph Systems, San Diego, California, USA) on a Macintosh computer. The X and Y coordinates of the landmarks were obtained relative to a horizontal reference plane 7 degrees up from the S-N plane at nasion, and the perpendicular to this plane at nasion (Figures 1–3).[14,15] The cephalometric landmarks and measurements are given in Table I. The analysis

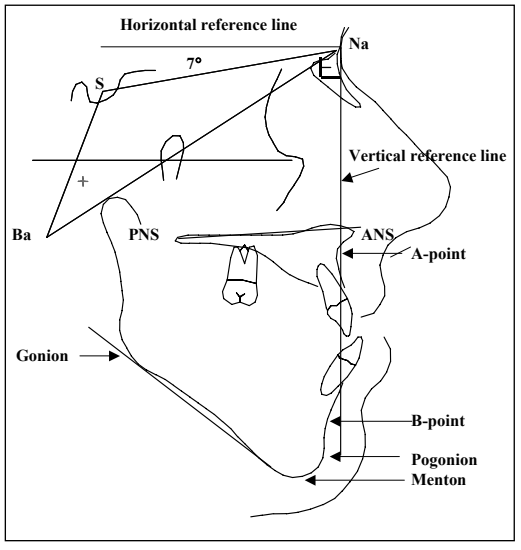



Figure 1. Lateral cephalometric radiographic landmarks.

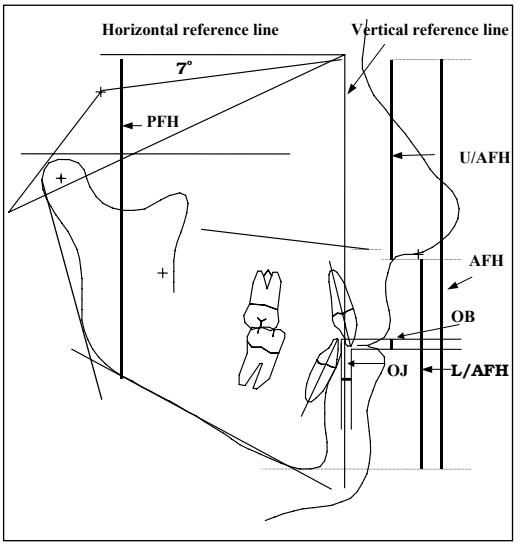



Figure 2. Linear measurements of lateral cephalometric landmarks.

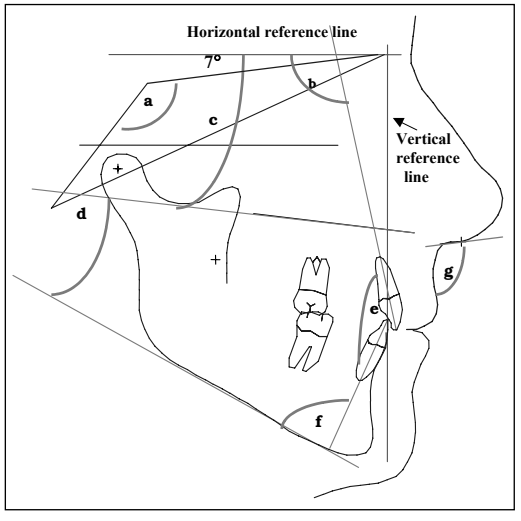



Figure 3. Measured angles of lateral cephalometric landmarks: (a) Cranial base angle, (b) Maxillary incisor inclination, maxillary incisor axis and horizontal reference line, (c) Palatal plane angle, palatal plane (ANS-PNS) and horizontal reference line, (d) Angulation between the mandibular plane and Palatal plane, (e) Inter-incisal angle, (f) Mandibular incisal inclination, mandibular incisor axis and mandibular plane, (g) Naso-labial angle, the intersection between columella/subnasale line and upper lip/subnasale line.

has been subdivided into maxillary position, mandibular position, and vertical relationships.

### *Cephalometric reliability and statistical analysis*

To ensure the reliability of landmark identification one week after the initial tracings, the radiographs of 10 randomly selected patients were retraced and redigitalised using the same methods, and the differences in landmark location tested with a two-tail paired *t*-test at a 95 per cent confidence interval.

The paired *t*-test was used to test for differences within the same group, and the non-paired *t*-test was used to compare the groups: Group A (Total sample), Group B (One-piece maxillary procedures), and Group C (Segmental maxillary procedures). Pearson product-moment correlation coefficients were used to determine the associations between the operative and follow-up changes in selected reference points in the maxilla and mandible. Probability values equal to or less than 0.05 were considered to be statistically significant. The data were analysed using the Minitab Personal Statistics Package (Macintosh Version, Minitab Inc., State College, Pennsylvania, USA).

## Results

The analysis of the lateral cephalometric radiographs was found to be reliable. The mean of the differences of 19 landmarks and eight parameters was 0.001 mm (SD: 0.6 mm). The standard error of the mean difference was less than 0.8 mm, and the

Table I. Cephalometric landmark abbreviations and measurements.

| Abbreviation | Cephalometric parameter | Abbreviation | Cephalometric parameter |
|---|---|---|---|
| A | A-point | Mx6 | Maxillary first molar |
| ANS | Anterior nasal spine | Na | Nasion |
| AFH | Anterior facial height | OJ | Overjet |
| B | B-point | OB | Overbite |
| Ba | Basion | Pal Pl | Palatal plane angle |
| Go | Gonion | PFH | Posterior facial height |
| Int | Interincisal angle | Pg | Pogonion |
| L/AFH | Lower anterior facial height | PNS | Posterior nasal spine |
| Md1 | Mandibular central incisor | L/AFH | Lower anterior facial height |
| Md6 | Mandibular first molar | S | Sella |
| Md Pl | Mandibular plane | SNA | Sella-nasion to A-point angle |
| Md1/Md Pl | Mandibular central incisor to mandibular plane | U/AFH | Upper anterior facial height |
| Me | Menton | X | Horizontal axis |
| Mx1 | Maxillary central incisor | Y | Vertical axis |
| Mx1/SN | Maxillary central incisor to sella-nasion plane | | |

differences between the first and second tracings were not significant ($p > 0.05$). The changes due to the operation (T1-T2), and the changes occurring in the follow-up period (T2-T3), are given in Tables II and III. Correlations between the operative (T1-T2) and follow-up (T2-T3) changes in the maxilla and mandible are given in Tables IV and V.

### *Operative changes*

The mean total movement of maxillary and mandibular repositioning was 9.7 mm (SD: 3.2 mm). The maxilla was advanced 6.1 mm (SD: 1.8 mm) with a significant range of 5.4 – 6.8 mm ($p < 0.001$), and impacted posteriorly 1.9 mm (SD: 2.1 mm). In 16 cases the maxilla was advanced less than 6.0 mm, and in 14 cases it was advanced between 6.0 and 11.5 mm (Figure 4).

The mandible at menton was setback, on average, 5.6 mm (SD: 4.2 mm) with a significant range of 3.2 – 6.9 mm ($p < 0.001$). Menton also rotated superiorly by 1.3 mm (SD: 2.5 mm) with a significant range of 0.3 – 2.2 mm ($p < 0.01$). Gonion, on the other hand, moved inferiorly 1.2 mm (SD: 2.4 mm) with a significant range of 0.3 – 2.0 mm ($p < 0.05$). The mandibular plane angle did not change significantly.

Anterior facial height (AFH) and lower anterior facial height (L/AFH) were reduced 1.3 mm (SD: 2.5 mm, $p < 0.009$) and 2.0 mm (SD: 2.6 mm, $p < 0.000$), respectively. There was no significant change in the posterior facial height (PFH).

### *Follow-up changes*

The maxilla relapsed posteriorly 0.6 mm (SD: 1.1 mm) with a significant range of 0.2 – 1.0 mm ($p < 0.01$). In 22 patients (73 per cent) the maxilla moved posteriorly less than 2.0 mm, whilst in eight cases (27 per cent) it moved anteriorly less than 2.0 mm

Table II. Cephalometric changes following combined maxillary advancement and mandibular reduction.

| | Operative change (T1 - T2) | | | | Follow-up changes (T2 - T3) | | | |
|---|---|---|---|---|---|---|---|---|
| Parameters | Mean | SD | 95 per cent CI | *p* | Mean | SD | 95 per cent CI | *p* |
| Maxilla | | | | | | | | |
| Max/X | 6.1 | 1.8 | 5.4, 6.8 | **0.000** | -0.6 | 1.1 | -1.0, -0.2 | **0.002** |
| Max/Y | -0.5 | 2.1 | -1.3, 0.3 | 0.17 | 0.5 | 1.6 | -0.1, 1.1 | 0.81 |
| PNS/X | 6.3 | 2.1 | 5.5, 7.1 | **0.000** | -0.7 | 1.1 | -1.1, -0.3 | **0.001** |
| ANS/X | 6.4 | 1.9 | 5.6, 7.1 | **0.000** | -0.7 | 1.0 | -1.1, -0.3 | **0.001** |
| A/X | 5.9 | 1.8 | 5.3, 6.6 | **0.000** | -0.6 | 1.1 | -1.0, -0.2 | **0.009** |
| Mx1/X | 4.7 | 1.9 | 4.0, 5.4 | **0.000** | 0.5 | 1.4 | 0.0, 1.1 | **0.038** |
| PNS/Y | 1.9 | 2.1 | 1.1, 2.7 | **0.000** | -0.3 | 1.7 | -1.0, 0.3 | 0.31 |
| ANS/Y | -0.7 | 2.5 | -1.7, 0.2 | 0.11 | 0.6 | 1.7 | -0.1, 1.2 | 0.079 |
| A/Y | -0.5 | 2.2 | -1.3, 0.4 | 0.25 | 0.5 | 1.7 | -0.1, 1.2 | 0.099 |
| Mx1/Y | -0.4 | 2.0 | -1.2, 0.3 | 0.25 | 0.6 | 1.6 | -0.0, 1.2 | 0.059 |
| SNA | 5.3 | 1.5 | 4.7, 5.8 | **0.000** | -0.5 | 1.0 | -0.9, -0.1 | **0.009** |
| Pal Pl | -2.7 | 3.1 | -3.9, -1.5 | **0.000** | 1.0 | 2.2 | 0.1, 1.8 | **0.023** |
| Mandible | | | | | | | | |
| Me/X | -5.6 | 4.2 | -6.9, -3.2 | **0.000** | 1.4 | 2.7 | 0.4, 2.4 | **0.007** |
| Go/X | 0.2 | 4.6 | -1.5, 2.0 | 0.79 | 0.4 | 3.2 | -0.8, 1.6 | 0.54 |
| Me/Y | 1.3 | 2.5 | 0.3, 2.2 | **0.009** | 0.9 | 2.5 | 0.0, 1.9 | **0.049** |
| Go/Y | -1.2 | 2.4 | -2.0, -0.3 | **0.012** | 1.5 | 2.3 | 0.7, 2.4 | **0.001** |
| Md Pl | -0.0 | 2.5 | -1.0, 0.9 | 0.93 | -0.2 | 1.8 | -0.8, 0.5 | 0.57 |
| Facial height | | | | | | | | |
| U/AFH | 0.7 | 2.5 | -0.2, 1.7 | 0.11 | -0.6 | 1.7 | -1.2, 0.1 | 0.079 |
| L/AFH | -2.0 | 2.6 | -3.0, -1.0 | **0.000** | -0.4 | 1.9 | -1.1, 0.3 | 0.25 |
| AFH | -1.3 | 2.5 | -2.2, -0.3 | **0.009** | -1.0 | 2.5 | -1.9, -0.1 | **0.032** |
| PFH | -0.2 | 0.5 | -0.3, 0.0 | 0.11 | 0.0 | 0.4 | -0.1, 0.2 | 0.68 |

Significant values are in bold.
Minus sign (-) indicates a lower value after comparison, that is, posterior movement in the horizontal plane or inferior movement in the vertical plane.

Table III. Cephalometric changes in occlusal landmarks following combined maxillary advancement and mandibular reduction.

| | Operative change (T1 - T2) | | | | Follow-up changes (T2 - T3) | | | |
|---|---|---|---|---|---|---|---|---|
| Parameters | Mean | SD | 95 per cent CI | *p* | Mean | SD | 95 per cent CI | *p* |
| Mx6/Y | 1.5 | 2.2 | 0.7, 2.4 | **0.000** | -0.0 | 1.4 | -0.5, 0.5 | 0.990 |
| Mx1/Y | -0.4 | 2.0 | -1.2, 0.3 | 0.250 | 0.6 | 1.6 | -0.0, 1.2 | 0.059 |
| Md6/Y | 1.8 | 2.4 | 0.9, 2.7 | **0.000** | 1.2 | 2.0 | 0.4, 1.9 | **0.003** |
| Md1/Y | 1.7 | 2.5 | 0.8, 2.6 | **0.000** | 1.1 | 2.4 | 0.2, 2.1 | **0.015** |
| Mx6/X | 4.5 | 2.6 | 3.5, 5.4 | **0.000** | 0.7 | 1.6 | 0.1, 1.3 | **0.034** |
| Mx1/X | 4.7 | 1.9 | 4.0, 5.3 | **0.000** | 0.5 | 1.4 | 0.0, 1.1 | **0.038** |
| Md6/X | -3.4 | 4.6 | -5.2, -1.7 | **0.000** | 0.7 | 1.6 | 0.1, 1.3 | **0.012** |
| Md1/X | -5.2 | 3.6 | -6.6, -3.8 | **0.000** | 0.5 | 1.4 | 0.0, 1.0 | **0.007** |
| Mx6/Y | 1.5 | 2.2 | 0.7, 2.4 | **0.000** | -0.0 | 1.4 | -0.5, 0.5 | 0.990 |
| Mx1/Y | -0.4 | 2.0 | -1.2, 0.3 | 0.250 | 0.6 | 1.6 | -0.0, 1.2 | 0.059 |
| Md1/Y | 1.7 | 2.5 | 0.8, 2.6 | **0.000** | 1.1 | 2.4 | 0.2, 2.1 | **0.015** |
| Mx1/SN | -1.6 | 5.2 | -3.5, 0.3 | 0.098 | 3.4 | 5.1 | 1.5, 5.3 | **0.000** |
| Md1/Md pl | 0.2 | 3.9 | -1.3, 1.6 | 0.810 | 0.8 | 4.5 | -0.9, 2.5 | 0.330 |
| OJ | 9.9 | 3.2 | 8.6, 11.1 | **0.000** | -0.3 | 1.1 | -0.7, 0.1 | 0.190 |
| OB | -2.1 | 2.2 | -3.0, -1.3 | **0.000** | -0.6 | 1.8 | -1.3, 0.1 | 0.094 |
| Int | 1.7 | 6.2 | -1.4, 4.8 | 0.260 | -2.7 | 6.1 | -5.0, -0.5 | **0.020** |

Significant values are in bold

Table IV. Correlation coefficients between the operative and follow-up changes in the maxilla following bimaxillary osteotomy.

| | PNS/Y | ANS/Y | A/Y | Mx1/Y | PNS/X | ANS/X | A/X | Mx1/X |
|---|---|---|---|---|---|---|---|---|
| DPNS/Y | -.567 | .120 | .060 | -.046 | .158 | .161 | .235 | .389 |
| DANS/Y | -.035 | -.435 | -.406 | -.354 | .239 | .135 | .143 | -.284 |
| DA/Y | -.084 | -.287 | -.344 | -.276 | .244 | .156 | .206 | -.159 |
| DMx1/Y | -.281 | -.293 | -.317 | .393 | .031 | -.046 | .032 | -.097 |
| DPNS/X | .018 | .211 | .256 | .157 | -.240 | -.196 | -.142 | .232 |
| DANS/X | .084 | .041 | .092 | .034 | -.243 | -.273 | -.183 | .100 |
| DA/X | .119 | .068 | .155 | .108 | -.137 | -.097 | -.147 | .102 |
| DMx1/X | .272 | -.219 | -.143 | -.110 | .396 | .344 | .398 | -.224 |

D refers to follow-up changes (T2-T3)

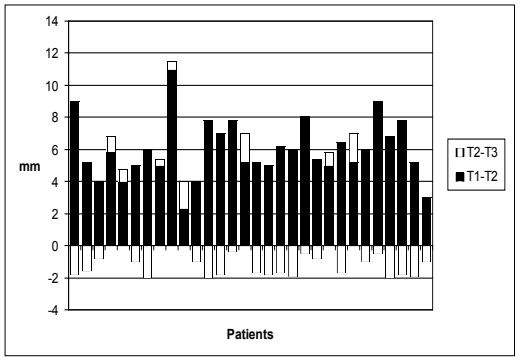



Figure 4. Horizontal change in the maxilla post-operatively (T1-T2) and at a minimum of 12-months follow-up (T2-T3).

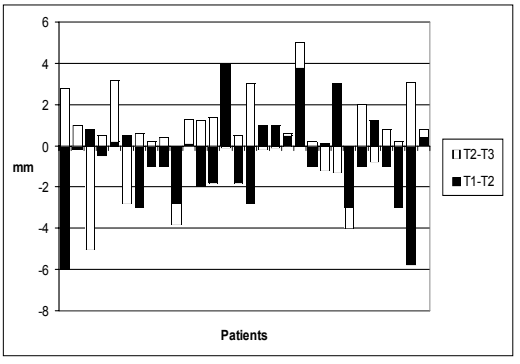



Figure 5. Vertical change in the maxilla post-operatively (T1-T2) and at a minimum of 12-months follow-up (T2-T3).

Table V. Correlation coefficients between the operative and follow-up changes in the mandible following bimaxillary osteotomy.

| | MeT2/Y | GoT2/Y | MeT2/X | GoT2/X | DMe/Y | DGo/Y | DMe/X |
|---|---|---|---|---|---|---|---|
| GoT2/Y | -.002 | | | | | | |
| MeT2/X | .255 | -.219 | | | | | |
| GoT2/X | .278 | -.312 | **.644** | | | | |
| DMe/Y | -.506 | -.341 | -.009 | -.057 | | | |
| DGo/Y | | -.242 | -.472 | .098 | .335 | .340 | |
| DMe/X | | -.153 | .091 | -.402 | -.478 | .356 | -.244 |
| DGo/X | | -.163 | .229 | -.383 | **-.743** | .201 | **-.601** |

D refers to follow-up changes (T2-T3)
Significant values are in bold

(Figure 4). The maxillary central incisors moved anteriorly 0.5 mm (SD: 1.4 mm), and the interincisal angle reduced significantly by 2.7 degrees (SD: 6.1 degrees) (Table III). Overall, the maxilla did not change vertically although there was considerable variability in both the direction and the magnitude of vertical movement (Figure 5).

The mandible at menton relapsed anteriorly 1.4 mm (SD: 2.7 mm), with a significant range of 0.4 – 2.4 mm ($p < 0.01$) (Figure 6). Menton also tended to move superiorly (Table II), however this was not significant. The mandible at gonion rotated superiorly 1.5 mm (SD: 2.3 mm, $p < 0.001$), but did not change its position horizontally. In 20 cases (67 per cent) menton moved anteriorly less than 2.5 mm, and in six cases it moved posteriorly up to 4.6 mm. Only four cases relapsed anteriorly greater than 2.5 mm anteriorly. While the AFH closed 1.0 mm (SD: 2.5 mm, $p < 0.05$), no changes occurred in either the L/AFH or the PFH.

### *Correlations*

No significant correlations were found between the operative (T1-T2) and follow-up (T2-T3) changes in the maxilla (Table IV). In the mandible, however, a significant association was found between the operative change at gonion (GoT2/X) and at menton (MeT2/X) (Table V). At follow-up, negative correlations were found between the changes at gonion and menton in the horizontal and vertical planes; DGo/X, DMe/X: r = -0.6 and DGo/X, DMe/Y: r = -0.74 respectively.

There were no significant differences between the maxillary and mandibular

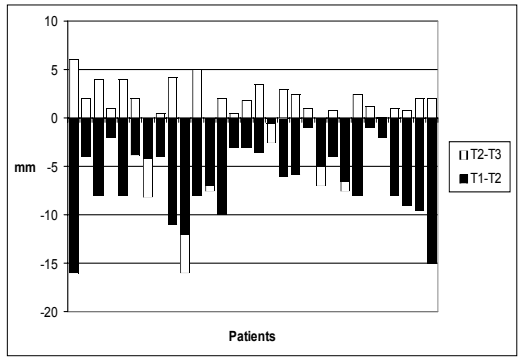



Figure 6. Horizontal change in the mandible, at menton, post-operatively (T1-T2) and at a minimum of 12-months follow-up (T2-T3).

positions, either post-operatively or at follow-up, between Groups A (whole sample), B (one-piece Le Fort I) or C (segmental Le Fort I) at follow-up.

## Discussion

The factors that influence post-operative stability have been investigated after single jaw surgery, bimaxillary procedures, with or without interpositional grafting, and with different methods of fixation, principally wire and mini-plate fixation.[3–9,13,16–20] The present study attempted to reduce the number of variables studied, and concentrated on the mean changes rather than individual cases. The cephalometric method was well controlled, and met the requirements of the study.[12]

The total anteroposterior correction, shared between the mandible and maxilla, was 9.7 mm. The mean maxillary advancement was 6.1 mm and, in agreement with previous studies of Le Fort I advancement as a single jaw procedure, relapsed 0.6 mm posteriorly after 12 months.[5,13,15,19,20] When the cephalometric tracing error is taken into account the amount of post-operative change in the maxilla is likely to be small. No significant differences in relapse in either the maxilla or mandible were found between the single-piece Le Fort I (Group B) and segmental Le Fort I (Group C) procedures indicating that segmental surgery does not contribute to instability and can be used to enhance the occlusal results when indicated.

The vertical changes in the maxilla, both post-operatively and at follow-up, were variable in both direction and amount and not statistically significant. Impaction of the maxilla posteriorly (PNS/Y) combined with no change anteriorly (ANS/Y) resulted in a clockwise rotation of the occlusal plane that may have contributed to the vertical stability of this procedure. This conclusion is supported by Enacar *et al.*[7] and Sarver *et al.*[21] who reported that posterior maxillary impaction and mandibular setback produced a clockwise rotation of the occlusal plane, which appeared to be stable. In a recent study Busby *et al.*[23] reviewed the stability of orthognathic procedures in Class III patients 5 years post-operatively. They reported that the maxillae, in the patients who had bimaxillary surgery, were more stable vertically than the maxillae in patients who had single-jaw maxillary advancement surgery.

Persson *et al.*[22] suggested that the large area of bony contact during posterior maxillary impaction accounted for the improved vertical stability. It could also be postulated that during the early phase of healing an intact mandible may exert greater occlusal and compressive forces on the teeth and maxilla than an operated mandible, thereby contributing to vertical instability.[9,14] It has been reported that rigid fixation and interpositional grafts improve the stability of the maxilla, particularly following advancements greater than 6 mm or vertical down-graft movements.[5,13,20]

The assessment of mandibular stability following bimaxillary procedures is somewhat complex because rotation of the proximal segment and autorotation can occur in three dimensions. Proffit *et al.*[9] analysed the stability of maxillary and mandibular procedures following correction of Class III malocclusion, and reported forward movement of gonion after surgery. Costa *et al.*[8] reported that forward movement of gonion was accompanied by a counterclockwise rotation of the proximal segment. The present study also demonstrated a superior rotation of gonion of 1.5 mm (SD: 2.3 mm) and an

accompanying counterclockwise rotation of the mandibular proximal fragment, that may contribute to stability.

It has been suggested that superior rotation of the proximal fragment of the mandible will increase the mechanical advantage of the masticatory muscles[8] with a consequent reduction in both muscle activity and compressive forces applied to the maxilla, especially anteriorly. Following superior repositioning of the maxilla the mandible autorotates in a counterclockwise direction, and can be set back without positioning the ramus inferiorly, and stretching the pterygomasseteric sling.

In the present study the mandible at menton was setback 5.6 mm and relapsed anteriorly 1.4 mm. The extent of this relapse is slightly less than that reported in previous studies, and may be due to methodological differences, different follow-up times, and/or unknown variables. For example, Costa and co-workers[8] recently reported a mean mandibular setback of 4.79 mm, measured at pogonion, which relapsed 2.97 mm. All patients had rigid internal fixation of the maxilla, and a bilateral sagittal split osteotomy of the mandible. The latter was stabilised with wire fixation and six weeks of intermaxillary fixation. Proffit *et al.*[9] classified their data on the direction of vertical movement of the maxilla, and reported the mandibular stability found in each group. Both rigid and wire fixation were used. In the maxillary impaction sample, pogonion relapsed 2.6 mm. Whereas in the group with minimal vertical maxillary movement, pogonion was setback 5 mm and relapsed 3.2 mm. A posterior movement at gonion of 2.9 mm was also recognised, and it was speculated that the moderate relapse observed was a factor in the subsequent forward movement of the mandible at gonion.[9] In the long-term study reported by Busby *et al.*[23] 80 per cent of the bimaxillary group relapsed less than 4 mm between 1 and 5 years post-operatively. During the first year mandibular setback was more stable when carried out with maxillary advancement. However, at the 5-year review mandibular setback alone was more stable (both vertically and horizontally) than mandibular setback combined with maxillary advancement. They suggested that this occurred because bimaxillary surgery was more likely to be used to treat severe Skeletal III malocclusions.[23]

Studies of mandibular reduction in bimaxillary and single jaw procedures support the proposition that post-operative neuromuscular imbalance, soft tissue tension and neuromuscular adaptation, affect the stability of the segments.[3,6,9,16] Superior rotation of the mandible suggests that the amount of anterior relapse at menton was a combination of skeletal relapse and the anterior movement of menton, and it is difficult to determine the relative contribution of each.

Overjet and overbite were maintained with minor dental compensation and both the maxillary and mandibular molar and incisor teeth moved anteriorly with no post-operative change in the vertical plane. Minor skeletal relapse, amounting to less than 2.0 mm, was camouflaged by dental compensation and post-operative orthodontic tooth movement.

This study demonstrated that combined maxillary advancement and mandibular setback procedures for the correction of Class III skeletal malocclusions, with rigid internal fixation, were relatively stable. There was no significant change in the vertical dimension, but the mandible tended to relapse anteriorly following the setback procedure. However, the minor degree of skeletal relapse was effectively managed with early post-operative inter-arch elastics and orthodontic treatment to maintain the occlusion.

## Acknowledgments

The support of the Melbourne Research Unit for Facial Disorders is gratefully acknowledged, together with the many orthodontists who provided patients for this study.

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