Aesthetic and reconstructive surgery

Skeletal and dento-alveolar stability of Le Fort I intrusion osteotomies and bimaxillary osteotomies in anterior open bite deformities

A retrospective three-centre study


Abstract. A sample of 267 patients with maxillary hyperplasia, a Class I or Class II/III occlusion and anterior vertical open bites, collected from three different institutions, was analysed regarding stability after surgical corrections. Skeletal and dento-alveolar stability of the maxilla, and positional changes of the mandible and of the incisors were evaluated. All patients underwent Le Fort I intrusion osteotomies and in 92 patients segmentation of the maxillae was performed. An additional bilateral sagittal split advancement osteotomy was performed in 123 patients. Intraosseous wire fixation was used in 153 patients and rigid internal fixation in 114 patients. Cephalometric radiographs were collected before orthodontic treatment, before surgery, immediately after surgery, one year postoperatively and at the latest follow up. The mean follow up was 69 months (range 20–210 months).

It can be concluded that patients with anterior open bites, treated with a Le Fort I osteotomy in one-piece or in multi-segments, with or without bilateral sagittal split osteotomy, exhibited good skeletal stability of the maxilla. Rigid internal fixation produced the best maxillary and mandibular stability. The mean overbite at the longest follow up was 1.24 mm and a lack of overlap between opposing incisors was present in 19%. The overbite did not differ significantly between the different treatment procedures, probably due to compensatory movements of the mandibular and maxillary incisors.

Surgical-orthodontic correction of anterior open bite deformities is known to be more difficult and less predictable than that of other dentofacial deformities. Variable rates of relapse have been reported after surgery15,17,24,43. Relapse has a skeletal and dento-alveolar component and its aetiology is considered to be multifactorial. General skeletal morphologic features of open bite deformities with a Class I or Class II occlusion are: increased mandibular plane angle; increased anterior facial height; increased lower anterior facial height; increased maxillary and mandibular posterior dento-alveolar height; and divergent occlusal planes15,23. In severe anomalies of
this type, a functionally and esthetically acceptable result cannot be attained by orthodontic treatment alone.\textsuperscript{6,11,12,22} Surgical orthodontic treatment planning should not only be based on skeletal assessment of the deformity\textsuperscript{12}, but also on posttreatment stability\textsuperscript{24}. The preferred surgical treatment has moved over the years from mandibular osteotomies, including segmental osteotomies, to maxillary procedures\textsuperscript{14}. At present, surgical superior repositioning and tilting of the maxilla, with or without bilateral mandibular ramus osteotomies, is usually the treatment of choice\textsuperscript{2,13}. A Le Fort I intrusion osteotomy and tilting is preferred in patients with only maxillary, posterior dentoalveolar hyperplasia. A Le Fort I intrusion osteotomy, with an additional advancement of the mandible using a bilateral sagittal split osteotomy (BSSO), is recommended for patients with maxillary, posterior dentoalveolar hyperplasia and mandibular hypoplasia.\textsuperscript{6,12,44} Procedures involving a Le Fort I osteotomy render more stable and predictable results than those obtained with only mandibular ramus osteotomies.\textsuperscript{6,13,20,31,33,39,41,49} Some studies have shown that bimaxillary osteotomies resulted in less mandibular but more maxillary relapse than in each of the separate osteotomies,\textsuperscript{6,20} while others have reported a comparable relapse tendency.\textsuperscript{19,45}

In earlier years, maxillary osteotomies were stabilized with intraosseous wires with or without intraorbital, circumzygomatic, or piriform rim suspension wires,\textsuperscript{16,25,30,36} while mandibular ramus osteotomies were stabilized by superior and inferior border wiring.\textsuperscript{49} In the 1980s, rigid fixation techniques using miniplates and/or screws were introduced to reduce postsurgical relapse.\textsuperscript{19,38,34,35,47} Many studies have been published on changes in maxillary position during and following orthognathic surgery.\textsuperscript{4,7,9,10,16,18,28,33,39,49} However, most of them did not take into account either the skeletal diagnosis on which the treatment was based or the quantification of magnitude and direction of changes.\textsuperscript{4}

Bishara et al.\textsuperscript{4} determined retrospectively the stability of the Le Fort I osteotomy after one-piece maxillary impaction and wire fixation in 31 patients, who had characteristics of vertical maxillary hyperplasia. Twelve of these patients also had a vertical anterior open bite. They found that after initial surgical superior repositioning, the maxilla continued to move superiorly and most of the upward movement occurred during the period of fixation.\textsuperscript{33,47} McCance et al.\textsuperscript{32} reported on ten Class II patients with a long face, high mandibular plane angle and anterior open bite, who underwent bimaxillary surgery. All patients had intraosseous wire fixation. They found variable relapse one year after maxillary intrusion. Kreisman et al.\textsuperscript{25} reported on 15 patients who underwent a bimaxillary osteotomy, using intraosseous wire osteosyntheses but without intermaxillary fixation. They found good stability after a one-year follow up. Lehman\textsuperscript{30} determined the stability of bimaxillary osteotomies in ten patients with anterior open bites. Skeletal relapse was found in two out of eight patients with a Class I or II. Although the use of wire fixation provided satisfactory results, the use of rigid internal fixation appeared to render better stability after bimaxillary ost­

tomies.\textsuperscript{5,29,38} Stratton et al.\textsuperscript{38} reported on 35 patients with vertical maxillary hyperplasia and mandibular hypoplasia who underwent a Le Fort I intrusion osteotomy combined with BSSO. They compared stability using rigid fixation \((n=26)\) versus wire fixation \((n=9)\). The maxilla was relatively stable with both fixation techniques and showed no significant differences, however, mandibles in the rigid fixation group were more stable during a 15-month follow-up period.

The tendency for the mandible and the maxilla to relapse seems to decrease when using rigid fixation,\textsuperscript{6,29} however, dento-alveolar changes may result in posttreatment instability.\textsuperscript{7,30,32} Studies on skeletal and dento-alveolar stability in a large group of patients with an open bite deformity are not available.

The purpose of this study was to evaluate a large group of patients, who underwent surgical-orthodontic correction of anterior skeletal open bite. The following parameters were assessed:

1. Skeletal and dentoalveolar stability of the maxilla following Le Fort I intrusion osteotomy, with or without a mandibular ramus osteotomy.
2. Positional changes of the mandible following only Le Fort I intrusion osteotomy.
3. Positional changes of the mandible following Le Fort I intrusion osteotomy combined with a mandibular ramus osteotomy.
4. Positional changes of mandibular and maxillary incisors and their interincisor relationship.
5. Influence of pre- and/or postoperative orthodontic treatment, a simul-
taneously performed mandibular ramus osteotomy and/or genioplasty, maxillary segmentation, and type of osteosynthesis on skeletal and dentoalveolar stability.

Material and methods

Patient selection

Patients included in this study:

1. had originally a Class I or Class II/1 occlusion combined with an anterior open bite, i.e. no vertical overlap of the central incisors, measured parallel to the mandibular occlusal plane.
2. had no history of trauma.
3. did not have amelogenesis imperfecta, or a presently known craniofacial syndrome.
4. underwent a Le Fort I osteotomy with posterior intrusion with or without a mandibular ramus osteotomy and/or genioplasty.
5. had cephalometric radiographs available preoperatively, immediately after surgery and in a later postoperative period.
6. had a minimum of one-year follow up after active orthodontic treatment.

A group of 267 patients (210 females and 57 males) fulfilled the selection criteria. The mean age of the patients before treatment was 23.6 years (range 14.3-45.5 years). Surgery was performed either in the department of Oral and Maxillofacial Surgery of the University Hospital, Nijmegen (n=72), the Rijnstate Hospital, Arnhem (n=72) or the Free University Hospital, Amsterdam (n=123). Orthodontic treatment to align the dental arches was combined with surgery in 203 patients.

Le Fort I osteotomy only was performed in 144 patients. After downfracturing of the maxilla, the appropriate amount of bone was removed at the lateral and medial sinus wall and the nasal septum to allow for the planned intrusion, as described by Epker13. The maxilla was cut in two or more pieces to achieve a proper occlusion in 92 out of 267 patients. A Le Fort I osteotomy was combined with a bilateral mandibular sagittal split advancement osteotomy in 123 patients. Maxillary segmentation in these bimaxillary osteotomies was performed in 25 patients. An additional genioplasty to improve facial harmony was performed in 136 patients (Table 1).

According to the type of internal fixation, patients were divided into a 'wire fixation' group and a 'rigid fixation' group. In the wire fixation group (n=153), intraosseous wires were used for stabilizing maxillary and/or mandibular osteotomies. Suspension wires using the piriform aperture or the zygomatic arch were used in almost all cases in this group. The period of intermaxillary fixation (IMF) was 4-6 weeks. In the rigid fixation group (n=114), mini- or microplates were used in the maxilla. Maxillary fixation with 2 wires and 2 plates was considered to be semi-rigid, however, this type of fixation was classified as rigid when IMF was omitted. Rigid fixation to stabilize the mandibular osteotomies was carried out with either miniplates37 or positional screws5.

Method of analysis

Lateral cephalometric radiographs were taken before orthodontic treatment (T1), preoperatively (T2), immediately postoperatively (T3), 6-19 months postoperatively (T4) and 20-210 months postoperatively (T5), i.e. at the last follow up (Table 2). The mean follow up was 69 months. The radiographs were taken with the patient oriented to the Frankfort Horizontal plane with the teeth in centric occlusion and the lips at rest. The one-year postoperative cephalometric radiograph (T4) was traced first, followed by T5, T3, T2 and T1. The radiographs were superimposed on sella, nasion, anterior and posterior cranial base using the "best-fit" method. The coordinates of 38 landmarks on each tracing were recorded with a digitizer (Hitachi29) and converted into linear and angular measurements by a software program made by one of the authors (S.J.A.M.N.). The cephalometric tracings were made and digitized by the first author. Linear and angular variables were measured for skeletal and dentoalveolar analysis.

A horizontal reference line (S’N) was constructed using a line through Nasion rotated 7° from the Sella-Nasion line4. This horizontal reference line approximates the Frankfort Horizontal plane and, therefore, is a correction for canting of the anatomic S-N line. The selected maxillary landmarks were: A point, Anterior Nasal Spine (ANS), Posterior Nasal Spine (PNS), the incisal edge of the maxillary first molar (+1), the mesiobuccal cusp tip of the maxillary first molar (+6). The selected mandibular landmarks were: B point, Menton (Me), Gonion (Go), the incisal edge of the mandibular central incisor (+1), the apex of the mandibular incisor (+1a), the mesiobuccal cusp tip of the mandibular first molar (+6). The used lines or planes were: Horizontal reference line (S’N), Sella-Nasion line (SN), Palatal Plane (PP) i.e. ANS-PNS, Occlusal Plane (OP) i.e. −li–6, Mandibular Plane (MP) i.e. Me-Go (Fig 1). The dental and skeletal landmarks

<table>
<thead>
<tr>
<th>Moment/interval</th>
<th>n</th>
<th>mean (months)</th>
<th>range</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 T1-T2</td>
<td>168</td>
<td>−19</td>
<td>(−90−1)</td>
<td>preoperative</td>
</tr>
<tr>
<td>T2 T2-T3</td>
<td>259</td>
<td>−3</td>
<td>(−13−1)</td>
<td>intraoperative</td>
</tr>
<tr>
<td>T3 T3-T4</td>
<td>267</td>
<td>0</td>
<td>(0−3)</td>
<td>early postoperative</td>
</tr>
<tr>
<td>T4 T4-T5</td>
<td>239</td>
<td>13</td>
<td>(6−19)</td>
<td>late postoperative</td>
</tr>
<tr>
<td>T5 T3-T5</td>
<td>262</td>
<td>69</td>
<td>(20−210)</td>
<td>overall postoperative</td>
</tr>
</tbody>
</table>

Table 2. Number of available cephalometric radiographs (N) at the different time moments and time intervals and the corresponding follow-up periods. The follow up is related to the moment of surgery.

Table 1. Overview of treatment characteristics

<table>
<thead>
<tr>
<th>Type of osteotomy</th>
<th>Fixation</th>
<th>Genioplasty</th>
<th>Orthodontics</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>wire</td>
<td>rigid</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Le Fort I (one-piece)</td>
<td>51</td>
<td>26</td>
<td>34</td>
<td>43</td>
</tr>
<tr>
<td>Le Fort I (multi-segm.)</td>
<td>49</td>
<td>18</td>
<td>34</td>
<td>33</td>
</tr>
<tr>
<td>Le Fort I (one-piece)+BSSO</td>
<td>37</td>
<td>61</td>
<td>56</td>
<td>42</td>
</tr>
<tr>
<td>Le Fort I (multi-segm.)+BSSO</td>
<td>16</td>
<td>9</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>All</td>
<td>153</td>
<td>114</td>
<td>136</td>
<td>131</td>
</tr>
</tbody>
</table>

BSSO: Bilateral sagittal split osteotomy
were used to establish the following linear and angular measurements in maxilla and mandible. Horizontal maxillary movements were assessed by the angular variables S-N-A and SN-PP. Vertical maxillary movements were measured by linear variables +1/PP and +6'/PP (Fig. 2). The two-dimensional position of the mandible was assessed by angular variables S-N-SPP, OP-MP and OP-MP.

The inclination of mandibular and maxillary incisors was measured by angular variables −1-MP, +1-PP and −1+I. Overbite is the distance between two lines drawn from +1l and −1l parallel to S′N. Overjet is the distance between two lines drawn from +11 and −11 perpendicular to S′N. Linear and angular changes in horizontal and vertical directions were measured for the consecutive time intervals: T1-T2, T2-T3, T3-T4, T4-T5, T3-T5. The corresponding intervals were, respectively, the preoperative period, the intraoperative period, the early postoperative period, the late postoperative period and the overall postoperative period. In patients who underwent active orthodontic treatment, the appliance was removed within the first postoperative year.

Statistical analysis
Statistical analysis was performed with SPSS (version 4.1 for IBM). The accuracy of landmark identification, superposition and measurements were evaluated by retracing three cephalometric radiographs at intervals T2, T3 and T4 of 19 randomly selected patients mixed over the three institutions. The error of measurement reliability. There were not enough significant variables found in the ANOVA for orthodontic treatment and genioplasty, taking into account the 75 tests (15 variables in 5 intervals). The patient sample in this study was not divided equally over the different institutions. Significant variables, however, were not specifically related to one particular institution. The results were nevertheless corrected for possible confounding. The presentation of the results will, therefore, be limited to type of osteotomy, segmentation of maxilla and type of fixation, since the tests related to these parameters showed a sufficient number of significances. No significant two-way interactions were found between different combinations of variables: type of osteotomy, segmentation of maxilla, type of fixation and institution giving treatment.

Cephalometric measurements refer to maxillary movements, mandibular position, and position of mandibular and maxillary incisors.

Maxillary movements
The mean changes of some variables concerning maxillary measurements in all patients are listed in Table 3. The vertical displacement of the maxillary incisors is due to extrusion of these teeth in the preoperative orthodontic period (T1-T2). The mean posterior maxillary surgical intrusion exceeded anterior maxillary surgical intrusion (T2-T3) and therefore, the palatal plane canted 4.08°. The S-N-A angle increased 1.11° due to this clockwise tilt and advancement of the maxilla. Postoperatively, the palatal plane and S-N-A declined respectively 0.21° and 0.18° (T3-T5). This skeletal relapse in horizontal direction was particularly seen in the early postoperative period and became less pronounced in the late...
Fig. 2. Cephalometric landmarks and linear and angular measurements used to evaluate dento-alveolar changes, overbite (OB) and overjet (OJ).

postoperative period. The anterior and posterior maxillary downward movements were respectively 0.28 mm and 0.52 mm during the overall post-operative period. The anterior maxillary downward movement was only 0.06 mm in the early postoperative period, however, it increased to 0.22 mm in the late postoperative period. The corresponding extrusion of maxillary incisors was 0.02 mm during the early postoperative period and 0.06 mm in the late postoperative period. The posterior maxillary downward movements were 0.15 mm in the early postoperative period and 0.38 mm in the late postoperative period. The extrusion of maxillary molars was respectively 0.04 mm and 0.21 mm in the corresponding time intervals.

The mean changes of maxillary measurements after Le Fort I osteotomy only, versus a bimaxillary osteotomy, were statistically not significantly different preoperatively and intraoperatively (Table 4). The horizontal skeletal movements were not significantly different postoperatively. The overall anterior maxillary downward movements and extrusion of incisors after a bimaxillary osteotomy, were significantly more than after a Le Fort I osteotomy only. In the late postoperative period, the posterior maxillary downward movements and extrusion of molars after a bimaxillary osteotomy were significantly more than those after a Le Fort I only. The overall displacements in the two groups, however, were not significantly different.

The effect on stability of segmentation of the maxilla in the Le Fort I procedure is shown in Table 5. The variables in the two groups were not significantly different in the preoperative period. The anterior and posterior superior repositioning and the advancement of the maxilla in the one-piece Le Fort I group were significantly more important. The results in the early postoperative and the late postoperative period were not statistically different, except for significantly more extrusion of maxillary molars following a Le Fort I osteotomy with segmentation in the late postoperative period.

Table 3. Mean changes of maxillary measurements in all patients

<table>
<thead>
<tr>
<th>Time intervals (n)</th>
<th>T1-T2 n=160</th>
<th>T2-T3 n=259</th>
<th>T3-T4 n=239</th>
<th>T4-T5 n=234</th>
<th>T5-T6 n=262</th>
<th>T6 n=262</th>
</tr>
</thead>
<tbody>
<tr>
<td>SN-PP (°)</td>
<td>0.06 ± 0.57</td>
<td>4.08 ± 3.39</td>
<td>-0.16 ± 0.84</td>
<td>-0.02 ± 0.85</td>
<td>-0.21 ± 1.14</td>
<td>6.34 ± 3.49</td>
</tr>
<tr>
<td>S-N-A (°)</td>
<td>-0.05 ± 0.45</td>
<td>1.11 ± 1.76</td>
<td>-0.10 ± 0.42</td>
<td>-0.06 ± 0.37</td>
<td>-0.18 ± 0.53</td>
<td>79.19 ± 4.32</td>
</tr>
<tr>
<td>+1/SN (mm)</td>
<td>0.48 ± 1.33</td>
<td>-1.19 ± 3.01</td>
<td>0.06 ± 0.77</td>
<td>0.22 ± 0.63</td>
<td>0.28 ± 0.90</td>
<td>85.74 ± 6.02</td>
</tr>
<tr>
<td>+1/PP (mm)</td>
<td>0.47 ± 1.15</td>
<td>-0.45 ± 1.80</td>
<td>0.02 ± 0.74</td>
<td>0.06 ± 0.76</td>
<td>0.09 ± 0.96</td>
<td>32.49 ± 3.65</td>
</tr>
<tr>
<td>+6/SN (mm)</td>
<td>0.14 ± 0.73</td>
<td>-3.40 ± 2.08</td>
<td>0.15 ± 0.71</td>
<td>0.38 ± 0.70</td>
<td>0.52 ± 0.96</td>
<td>80.33 ± 5.21</td>
</tr>
<tr>
<td>+6/PP (mm)</td>
<td>0.20 ± 0.60</td>
<td>-0.58 ± 1.36</td>
<td>0.04 ± 0.54</td>
<td>0.21 ± 0.70</td>
<td>0.24 ± 0.86</td>
<td>26.66 ± 2.92</td>
</tr>
</tbody>
</table>

The effects of intraosseous wire fixation versus rigid fixation on the stability of the maxilla following a Le Fort I osteotomy is presented in Table 6. Changes in variables were not significantly different in the two groups preoperatively. The group with rigid fixation underwent more maxillary advancement (S-N-A) during surgery. Surgical superior repositioning of the maxilla was carried out more in the wire fixation group. The S-N-A angle declined significantly more in the rigid fixation group in the early postoperative period. In the same period, the wire fixation group showed a tendency to more anterior upward movements, whereas the rigid fixation group showed some downward movements. The differences were, however, not statistically significant. The maxillary downward movements and extrusion of incisors were not significantly different in the two groups.
movements and extrusion of incisors and molars, however, were significantly more in the wire fixation group in the late postoperative period.

Mandibular position

The mean positional changes of the mandible in all patients are listed in Table 7. The S-N-B angle decreased 0.15°, the divergence between PP and OP increased 0.24° and between PP and MP increased 0.06° pre-operatively. Counterclockwise rotation and/or advancement of the mandible resulted in a 2.74° increase of S-N-B. The palatal plane, occlusal plane and the mandibular plane showed declining mutual divergences due to surgery. The S-N-B, PP-OP and PP-MP angles increased again in the early and late postoperative periods.

The mean changes of mandibular measurements after an isolated Le Fort I osteotomy versus a bimaxillary osteotomy are listed in Table 8. In the pre-operative period, the variables in the two groups were not significantly different. The S-N-B angle increased significantly more in the bimaxillary group due to the mandibular advancement, however, it decreased during the early postoperative period and continued in the late postoperative period. The intra-operative PP-OP angle reduction was significantly more in the bimaxillary group, however, no significant differences were found between the two osteotomy types in the postoperative periods. The increase of divergence between the palatal plane (PP) and the mandibular plane (MP) in the bimaxillary group was significantly more in the early postoperative period. These statistically significant differences disappeared in the late postoperative period.

The mean changes of mandibular measurements after a one-piece or multi-segment Le Fort I osteotomy are listed in Table 9. The one-piece Le Fort I showed a significantly greater increase of S-N-B. No differences could be found postoperatively. The PP-OP angle declined significantly more in the one-piece Le Fort I group in the early post-operative period. The PP-MP angle was not significantly different in either time interval.

The effects of internal wire fixation or rigid fixation are presented in Table 10. The variables were not significantly different in the preoperative period or in the intraoperative period. The significant decline of S-N-B was noticed in the wire fixation group in the early postoperative period. The PP-OP angle increased significantly in the wire fixation group in the same period. The divergence between PP and MP increased significantly more in the wire fixation group as compared with the plate group in the early and late postoperative periods.

Mandibular and maxillary incisors

The mean positional changes of mandibular and maxillary incisors in all patients are listed in Table 11. The pre-operative orthodontic treatment resulted in a 1.93° retrusion of the maxillary incisors, and a 0.52° protrusion of the mandibular incisors. The interincisor angle increased by 1.35°, the negative overbite was reduced by 0.32 mm, and the overjet was reduced by 1.11 mm. A more upright position of the maxillary incisors, increased interincisor angle, reduced overjet and positive overbite were created intraoperatively. The maxillary incisors protruded gradually postoperatively. The inclination of the mandibular incisors remained unchanged. Consequently, the interincisor angle decreased, the overjet increased, and the positive overbite decreased in the early and late postoperative periods.

The mean changes in interincisor relationship after a Le Fort I osteotomy and after a bimaxillary osteotomy are compared in Table 12. The protrusive movement of the mandibular incisors increased in the Le Fort I group, but decreased in the bimaxillary group preoperatively. The relapse overbite was not significantly different in the two groups, however, the relapse of overjet was more in the bimaxillary group. The protrusion of the mandibular incisors increased by 0.22° in the Le Fort I group, and declined by 0.56° in the bimaxillary group in the late postoperative period.

The effects of segmentation of the maxilla on the position of the maxillary incisors are shown in Table 13. The segmentation group and the one-piece Le Fort I group did not show significant differences preoperatively. Segmentation of the maxilla resulted in a more upright position of the maxillary incisors. The mandibular incisors showed significantly more protrusion, and the overbite showed significantly more relapse, in the one-piece Le Fort I osteotomy in the early postoperative period compared to the multi-segment Le Fort I osteotomy.

The group that was stabilized with intraosseous wires, was compared with the group in which rigid internal fixation was used (Table 14). More protrusion of the mandibular incisors was reached preoperatively in the rigid fixation group. The negative overbite, however, was more reduced in the wire fixation group preoperatively. Except for the overall increase of overjet in the group that was treated with wire fixation, other dento-alveolar changes were not significantly different postoperatively.

The mean overbite after a 69-month follow-up period was 1.24 mm. A lacking vertical overlap between opposing central incisors was present in 19% of the patients. No statistically significant differences between the different groups were found in a two-way analysis for overbite.

Discussion

Cephalometric analyses of patients undergoing surgical-orthodontic treatment are fraught with problems related to identification of landmarks. Landmarks can be altered by orthodontic treatment, by surgery and by bone remodelling. It is

Fig. 3 A-C. Preoperative frontal and profile views and occlusion of patient with maxillary posterior hyperplasia, mandibular hypoplasia and anterior open bite.
Fig. 3 D-F. Postoperative views 6 months after Le Fort I intrusion osteotomy and tilting combined with bilateral sagittal split advancement osteotomy and advancement genioplasty. Maxillary and mandibular osteotomies have been stabilized with intraosseous wire osteosynthesises and circumzygomatic suspension wires. Facial harmony and occlusion have been improved.
Fig. 3 G-I. Postoperative views 3 1/2 years after surgical correction. Interdigitation has deteriorated, overbite decreased, overjet increased, while facial features did not change.
### Table 4. Mean changes of maxillary measurements after Le Fort I osteotomy versus bimaxillary osteotomy

<table>
<thead>
<tr>
<th>Time intervals</th>
<th>T₁-T₂</th>
<th>T₁-T₃</th>
<th>T₁-T₄</th>
<th>T₁-T₅</th>
<th>T₁-T₆</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n)</td>
<td>mean</td>
<td>SD</td>
<td>P</td>
<td>mean</td>
<td>SD</td>
</tr>
<tr>
<td>SN-PP (*)</td>
<td>0.12</td>
<td>0.01</td>
<td>0.56</td>
<td>NS</td>
<td>3.09</td>
</tr>
<tr>
<td>S-N-A (*)</td>
<td>-0.04</td>
<td>-0.09</td>
<td>0.47</td>
<td>NS</td>
<td>0.90</td>
</tr>
<tr>
<td>+1/S'N (mm)</td>
<td>0.60</td>
<td>0.33</td>
<td>1.33</td>
<td>NS</td>
<td>-1.09</td>
</tr>
<tr>
<td>+1/PP (mm)</td>
<td>0.55</td>
<td>0.39</td>
<td>1.15</td>
<td>NS</td>
<td>-0.50</td>
</tr>
<tr>
<td>+6/S'N (mm)</td>
<td>0.18</td>
<td>0.11</td>
<td>0.75</td>
<td>NS</td>
<td>-3.40</td>
</tr>
<tr>
<td>+6/PP (mm)</td>
<td>0.21</td>
<td>0.20</td>
<td>0.60</td>
<td>NS</td>
<td>-0.74</td>
</tr>
</tbody>
</table>

NS: Not significant. *: P<0.05. **: P<0.01. I: Le Fort I osteotomy. B: Bimaxillary osteotomy.

### Table 5. Mean changes of maxillary measurements after one-piece Le Fort I osteotomy versus multi-segment Le Fort I osteotomy

<table>
<thead>
<tr>
<th>Time intervals</th>
<th>T₁-T₂</th>
<th>T₁-T₃</th>
<th>T₁-T₄</th>
<th>T₁-T₅</th>
<th>T₁-T₆</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n)</td>
<td>mean</td>
<td>SD</td>
<td>P</td>
<td>mean</td>
<td>SD</td>
</tr>
<tr>
<td>SN-PP (*)</td>
<td>0.16</td>
<td>-0.06</td>
<td>0.56</td>
<td>NS</td>
<td>4.08</td>
</tr>
<tr>
<td>S-N-A (*)</td>
<td>-0.03</td>
<td>-0.10</td>
<td>0.47</td>
<td>NS</td>
<td>1.37</td>
</tr>
<tr>
<td>+1/S'N (mm)</td>
<td>0.55</td>
<td>0.38</td>
<td>1.33</td>
<td>NS</td>
<td>-1.83</td>
</tr>
<tr>
<td>+1/PP (mm)</td>
<td>0.47</td>
<td>0.49</td>
<td>1.15</td>
<td>NS</td>
<td>-0.66</td>
</tr>
<tr>
<td>+6/S'N (mm)</td>
<td>0.19</td>
<td>0.23</td>
<td>0.03</td>
<td>NS</td>
<td>-3.66</td>
</tr>
<tr>
<td>+6/PP (mm)</td>
<td>0.27</td>
<td>0.13</td>
<td>0.60</td>
<td>NS</td>
<td>-0.36</td>
</tr>
</tbody>
</table>

NS: Not significant. *: P<0.05. **: P<0.01.

### Table 6. Mean changes of maxillary measurements after Le Fort I osteotomy with intraosseous wire fixation versus rigid internal fixation

<table>
<thead>
<tr>
<th>Time intervals</th>
<th>T₁-T₂</th>
<th>T₁-T₃</th>
<th>T₁-T₄</th>
<th>T₁-T₅</th>
<th>T₁-T₆</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n)</td>
<td>mean</td>
<td>SD</td>
<td>P</td>
<td>mean</td>
<td>SD</td>
</tr>
<tr>
<td>SN-PP (*)</td>
<td>0.03</td>
<td>0.13</td>
<td>0.56</td>
<td>NS</td>
<td>4.01</td>
</tr>
<tr>
<td>S-N-A (*)</td>
<td>-0.02</td>
<td>-0.11</td>
<td>0.47</td>
<td>NS</td>
<td>0.81</td>
</tr>
<tr>
<td>+1/S'N (mm)</td>
<td>0.57</td>
<td>0.36</td>
<td>1.33</td>
<td>NS</td>
<td>-1.55</td>
</tr>
<tr>
<td>+1/PP (mm)</td>
<td>0.57</td>
<td>0.36</td>
<td>1.15</td>
<td>NS</td>
<td>-0.61</td>
</tr>
<tr>
<td>+6/S'N (mm)</td>
<td>0.13</td>
<td>0.15</td>
<td>0.15</td>
<td>NS</td>
<td>-3.76</td>
</tr>
<tr>
<td>+6/PP (mm)</td>
<td>0.18</td>
<td>0.25</td>
<td>0.60</td>
<td>NS</td>
<td>-0.78</td>
</tr>
</tbody>
</table>

NS: Not significant. *: P<0.05. **: P<0.01. WF: Wire fixation. RF: Rigid fixation.
difficult to distinguish between orthodontically related postsurgical changes and those occurring from skeletal instability. Dental changes can accentuate or conceal skeletal changes. In a two-dimensional analysis of cephalometric radiographs, it should be kept in mind that it is not possible to evaluate the transverse stability of the dental arch.

All patients had undergone treatment for correction of a severe anterior open bite. They were subdivided according to the surgical procedures performed, i.e. Le Fort I osteotomy versus bimaxillary osteotomy, wire fixation versus rigid fixation, one-piece Le Fort I osteotomy versus multi-segment Le Fort I osteotomy. No statistically different interactions were found between the different groups.

The stability of the surgical procedure was proven not to be influenced by gender, age, growth, orthodontic treatment, amount of surgical displacement at Le Fort I level, maxillary segmentation, period of IMF, or additionally performed genioplasty. Statistical analysis in this study produced no significant influence of orthodontic treatment and performed genioplasty on stability.

The patients in this three-centre study were treated by a considerable number of different orthodontists and surgeons. This is probably of influence when evaluating stability. PROFT et al. found no correlation between maxillary stability and the surgeons who performed Le Fort I intrusion osteotomies. SCHENDEL & EKER, however, suggested in a report on mandibular surgery that the skill of the surgeon is the most important variable when explaining postsurgical stability.

Table 7. Mean changes of mandibular measurements in all patients

<table>
<thead>
<tr>
<th>Time intervals</th>
<th>T1-T2</th>
<th>T2-T3</th>
<th>T3-T4</th>
<th>T4-T5</th>
<th>T5-T6</th>
<th>T6-T7</th>
<th>T7-T8</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n)</td>
<td>mean</td>
<td>SD</td>
<td>mean</td>
<td>SD</td>
<td>mean</td>
<td>SD</td>
<td>mean</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S-N-B (°)</td>
<td>-0.15</td>
<td>0.69</td>
<td>2.74</td>
<td>1.92</td>
<td>-0.74</td>
<td>0.98</td>
<td>-0.46</td>
</tr>
<tr>
<td>PP-OP (°)</td>
<td>0.24</td>
<td>2.55</td>
<td>-7.32</td>
<td>4.87</td>
<td>0.99</td>
<td>2.42</td>
<td>1.00</td>
</tr>
<tr>
<td>PP-MP (°)</td>
<td>0.06</td>
<td>1.22</td>
<td>-6.78</td>
<td>5.02</td>
<td>1.27</td>
<td>1.80</td>
<td>0.87</td>
</tr>
<tr>
<td>OP-MP (°)</td>
<td>-0.17</td>
<td>2.47</td>
<td>-1.21</td>
<td>4.04</td>
<td>0.16</td>
<td>2.19</td>
<td>-0.16</td>
</tr>
</tbody>
</table>

Presurgical orthodontics should aim at elimination of dental compensation and alignment of the dental arches as much as possible. The mandibular incisors should be retracted and placed on the apical basis with a normal axial inclination. Maxillary expansion carries the risk of relapse with subsequent extrusion of posterior teeth after treatment. Preoperative retraction of maxillary incisors should be prevented in most cases because a Le Fort I osteotomy with posterior intrusion will accentuate the upright position of the maxillary incisors. If this movement is anticipated, rather more protrusion of the maxillary incisors should be considered presurgically.

Postsurgical maxillary stability

The results of this study showed that maxillary stability in the horizontal direction was better than in the vertical direction. Movements of the maxilla in the horizontal direction occurred particularly in the early postoperative period, while changes in the vertical direction were more obvious in the late postoperative period. Vertical maxillary movements are composed of a skeletal and a dento-alveolar component and, therefore, maxillary vertical skeletal movements have to be corrected for intrusions or extrusions of teeth. Extrusion of maxillary molars, for example (0.21 mm), formed a main component of posterior maxillary downward movement (0.38 mm) in the late postoperative period and contributed to a downward-backward rotation of the mandible (Table 3). Postoperative displacement of teeth can be attributed to orthodontic tooth movement, relapse of the transverse dimension of the orthodontically or surgically expanded maxillary arch, or continued eruption of maxillary molars after the orthodontic treatment. These dento-alveolar changes will deteriorate occlusal interdigitation and consequently will reduce overbite.


turvey et al. studied simultaneous superior repositioning of the maxilla and mandibular advancement. They compared a group of patients who underwent a one-piece Le Fort I osteotomy with a group who underwent a multi-segment Le Fort I intrusion osteotomy. The multi-segment maxillary group tended to be more stable than the one-piece maxillary group for at least one year after surgery. We found no significant differences in stability between the two groups in this study, however, relapse of overbite was significantly less in the multi-segment group in the early postoperative period. Extrusion of maxillary molars was more pronounced in the multi-segment maxillary group in the late postoperative period. Segmentation of the maxilla in a Le Fort I osteotomy had a minor effect on overall maxillary stability and position of the mandible. These findings are in accordance with those of Bailey et al.

Le Fort I osteotomy

The vertical changes of the maxillary incisors and first molars following a Le Fort I osteotomy with wire fixation in this study were similar to those reported in previous studies. PROFT et al. reported that during the first year, the vertical position of the maxilla was stable in approximately 80% of 61 patients, who were treated with surgical superior repositioning of the maxilla and wire fixation. Postsurgical move-
### Table 8. Mean changes of mandibular measurements after Le Fort I osteotomy versus bimaxillary osteotomy

<table>
<thead>
<tr>
<th>Time intervals</th>
<th>( \Delta_{T_1-T_2} )</th>
<th>( \Delta_{T_2-T_3} )</th>
<th>( \Delta_{T_3-T_4} )</th>
<th>( \Delta_{T_4-T_5} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( T )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
</tr>
<tr>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
</tr>
<tr>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
</tr>
<tr>
<td>S-N-B (°)</td>
<td>-0.18</td>
<td>1.81</td>
<td>-0.31</td>
<td>-0.69</td>
</tr>
<tr>
<td>( \text{mean} )</td>
<td>-0.11</td>
<td>1.80</td>
<td>-0.61</td>
<td>-0.74</td>
</tr>
<tr>
<td>( \text{mean} )</td>
<td>0.69</td>
<td>1.62</td>
<td>0.63</td>
<td>1.07</td>
</tr>
</tbody>
</table>
| NS: Not significant. *: \( P<0.05 \). **: \( P<0.01 \). I: Le Fort I osteotomy. B: Bimaxillary osteotomy.

### Table 9. Mean changes of mandibular measurements after a one-piece Le Fort I osteotomy versus multi-segment Le Fort I osteotomy

<table>
<thead>
<tr>
<th>Time intervals</th>
<th>one-</th>
<th>multi-</th>
<th>one-</th>
<th>multi-</th>
<th>one-</th>
<th>multi-</th>
<th>one-</th>
<th>multi-</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta_{T_1-T_2} )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
</tr>
<tr>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
</tr>
<tr>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
</tr>
<tr>
<td>S-N-B (°)</td>
<td>-0.10</td>
<td>2.97</td>
<td>-0.83</td>
<td>-0.44</td>
<td>-1.21</td>
<td>-1.00</td>
<td>-1.07</td>
<td>-1.07</td>
</tr>
<tr>
<td>( \text{mean} )</td>
<td>-0.22</td>
<td>2.27</td>
<td>-0.57</td>
<td>-0.50</td>
<td>-1.10</td>
<td>-1.00</td>
<td>-1.07</td>
<td>-1.07</td>
</tr>
<tr>
<td>( \text{mean} )</td>
<td>0.69</td>
<td>1.62</td>
<td>0.84</td>
<td>0.63</td>
<td>1.07</td>
<td>1.00</td>
<td>1.07</td>
<td>1.07</td>
</tr>
</tbody>
</table>
| NS: Not significant. *: \( P<0.05 \). **: \( P<0.01 \). I: Le Fort I osteotomy. B: Bimaxillary osteotomy.

### Table 10. Mean changes of mandibular measurements after a Le Fort I osteotomy with intraosseous wire fixation versus rigid internal fixation

<table>
<thead>
<tr>
<th>Time intervals</th>
<th>WF</th>
<th>RF</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta_{T_1-T_2} )</td>
<td>( \text{mean} )</td>
<td>( \text{mean} )</td>
</tr>
<tr>
<td>( \text{SD} )</td>
<td>( \text{SD} )</td>
<td></td>
</tr>
<tr>
<td>( \text{P} )</td>
<td>( \text{P} )</td>
<td></td>
</tr>
<tr>
<td>S-N-B (°)</td>
<td>-0.18</td>
<td>2.83</td>
</tr>
<tr>
<td>( \text{mean} )</td>
<td>-0.11</td>
<td>2.62</td>
</tr>
<tr>
<td>( \text{mean} )</td>
<td>0.69</td>
<td>1.62</td>
</tr>
</tbody>
</table>
| NS: Not significant. *: \( P<0.05 \). **: \( P<0.01 \). WF: Wire fixation. RF: Rigid fixation.
ment of skeletal landmarks over 2 mm or more was seen in 20% of the cases. During the IMF period, the maxilla had a tendency to move further superiorly, but these changes were followed by inferior movement from the time of IMF release to one-year follow up, therefore, only 6.5% had 2 mm or more net vertical movement from immediate postsurgery to one year. Brighara et al. found continued anterior upward movement of 1.31 mm and a posterior upward movement of 0.29 mm after a mean postsurgical period of 132 days. Bailey et al. also found, respectively, 0.72 mm and 0.15 mm upward movements one year postsurgically. In both aforementioned studies, wire osteosynthesis was used. A maxillary upward movement during the first year after superior repositioning of the maxilla when using intraosseous wire fixation, is confirmed by other authors. This postsurgical movement is most likely related to resorption and remodelling at the osteotomy sites, and is probably enhanced by tightening of the suspension wires.

The initial maxillary upward movements within the first postsurgical year were followed by downward movements. According to Bailey et al. only 6.5% of the patients had 2 mm or more downward movements of skeletal or dental landmarks at one year after a Le Fort I intrusion osteotomy and wire fixation, but approximately 25% of the patients showed 2 mm or more downward movement of the maxilla and/or extrusion of maxillary teeth from one to five years postsurgery. The reported displacement of incisor and first molar was respectively 1.05 mm and 1.23 mm after a five-year follow up. In this study, however, these values in the late postsurgical period were 0.35 mm and 0.55 mm, which are considerably less. Postsurgical orthodontics, elastic traction and relapse of transverse dimension are possible explanations for dental extrusion.

Larsen et al. compared postsurgical maxillary movements in 30 patients whose maxillary osteotomies were stabilized with intraosseous wire osteosyntheses (n=17) versus those with rigid internal fixation (n=13). They found similar maxillary movement for both groups during the first six months postsurgery. The maxilla stabilized with plate fixation, however, was more stable in the period from six months to one year, as well as during the overall postsurgical period. Kahlenberg et al. also compared both types of fixation in a group of 19 patients with anterior open bites, who underwent a Le Fort I osteotomy. Significant difference was found between the group in which wire fixation (n=9) was used, and the group in which plate fixation (n=10) was used, respectively 6 months and 18 months postsurgically. The findings in our study were not statistically significant either for the early postsurgical period. Rigid internal fixation, however, produced significantly better maxillary stability than intraosseous wire fixation in the late postsurgical period.

**Bimaxillary procedures**

There are various reports in the literature on stability of the maxilla after bimaxillary surgery. Few studies have quantified maxillary, mandibular and dento-alveolar measurements in a manner that permits comparison with the results reported in this study. Krakenov and/or extrusion of maxillary teeth from one to five years postsurgery. The reported displacement of incisor and first molar was respectively 1.05 mm and 1.23 mm after a five-year follow up. In this study, however, these values in the late postsurgical period were 0.35 mm and 0.55 mm, which are considerably less. Postsurgical orthodontics, elastic traction and relapse of transverse dimension are possible explanations for dental extrusion.

Larsen et al. compared postsurgical maxillary movements in 30 patients whose maxillary osteotomies were stabilized with intraosseous wire osteosyntheses (n=17) versus those with rigid internal fixation (n=13). They found similar maxillary movement for both groups during the first six months postsurgery. The maxilla stabilized with plate fixation, however, was more stable in the period from six months to one year, as well as during the overall postsurgical period. Kahlenberg et al. also compared both types of fixation in a group of 19 patients with anterior open bites, who underwent a Le Fort I osteotomy. Significant difference was found between the group in which wire fixation (n=9) was used, and the group in which plate fixation (n=10) was used, respectively 6 months and 18 months postsurgically. The findings in our study were not statistically significant either for the early postsurgical period. Rigid internal fixation, however, produced significantly better maxillary stability than intraosseous wire fixation in the late postsurgical period.

**Table 11. Mean changes of dento-alveolar measurements in all patients**

<table>
<thead>
<tr>
<th>Time intervals (n)</th>
<th>T1-T2</th>
<th>T2-T3</th>
<th>T3-T4</th>
<th>T4-T5</th>
<th>T5-T6</th>
<th>T1-T6</th>
<th>T2-T7</th>
<th>T3-T8</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>SD</td>
<td>mean</td>
<td>SD</td>
<td>mean</td>
<td>SD</td>
<td>mean</td>
<td>SD</td>
</tr>
<tr>
<td>+1-PP (°)</td>
<td>-1.93</td>
<td>6.35</td>
<td>-0.90</td>
<td>4.93</td>
<td>0.36</td>
<td>3.60</td>
<td>0.40</td>
<td>2.88</td>
</tr>
<tr>
<td>-1-1-MP (°)</td>
<td>0.52</td>
<td>6.10</td>
<td>2.04</td>
<td>4.68</td>
<td>0.22</td>
<td>3.32</td>
<td>-0.15</td>
<td>2.73</td>
</tr>
<tr>
<td>-1-1+1 (°)</td>
<td>1.35</td>
<td>9.86</td>
<td>7.64</td>
<td>6.65</td>
<td>-1.86</td>
<td>5.41</td>
<td>-1.12</td>
<td>4.04</td>
</tr>
<tr>
<td>overbite (mm)</td>
<td>0.32</td>
<td>1.62</td>
<td>3.10</td>
<td>2.74</td>
<td>-0.28</td>
<td>1.19</td>
<td>-0.37</td>
<td>0.96</td>
</tr>
<tr>
<td>overjet (mm)</td>
<td>-1.11</td>
<td>2.53</td>
<td>-4.84</td>
<td>3.02</td>
<td>0.71</td>
<td>1.40</td>
<td>0.75</td>
<td>1.25</td>
</tr>
</tbody>
</table>

**Table II. Mean changes of dento-alveolar measurements in all patients**

<table>
<thead>
<tr>
<th>Time intervals (n)</th>
<th>T1-T2</th>
<th>T2-T3</th>
<th>T3-T4</th>
<th>T4-T5</th>
<th>T5-T6</th>
<th>T1-T6</th>
<th>T2-T7</th>
<th>T3-T8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
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<td>mean</td>
<td>SD</td>
<td>mean</td>
<td>SD</td>
<td>mean</td>
<td>SD</td>
</tr>
<tr>
<td>+1-PP (°)</td>
<td>-1.93</td>
<td>6.35</td>
<td>-0.90</td>
<td>4.93</td>
<td>0.36</td>
<td>3.60</td>
<td>0.40</td>
<td>2.88</td>
</tr>
<tr>
<td>-1-1-MP (°)</td>
<td>0.52</td>
<td>6.10</td>
<td>2.04</td>
<td>4.68</td>
<td>0.22</td>
<td>3.32</td>
<td>-0.15</td>
<td>2.73</td>
</tr>
<tr>
<td>-1-1+1 (°)</td>
<td>1.35</td>
<td>9.86</td>
<td>7.64</td>
<td>6.65</td>
<td>-1.86</td>
<td>5.41</td>
<td>-1.12</td>
<td>4.04</td>
</tr>
<tr>
<td>overbite (mm)</td>
<td>0.32</td>
<td>1.62</td>
<td>3.10</td>
<td>2.74</td>
<td>-0.28</td>
<td>1.19</td>
<td>-0.37</td>
<td>0.96</td>
</tr>
<tr>
<td>overjet (mm)</td>
<td>-1.11</td>
<td>2.53</td>
<td>-4.84</td>
<td>3.02</td>
<td>0.71</td>
<td>1.40</td>
<td>0.75</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Two out of eight patients with a Class I or Class II skeletal relationship were considered to have more than 1.5 mm relapse in the horizontal or vertical direction. In all patients relapse occurred, particularly in the mandible, within the first year postoperatively. Braemer et al. reported on stability in 12 patients with vertical maxillary hyperplasia and mandibular hypoplasia, who underwent a Le Fort I intrusion osteotomy and BSSO with intraosseous wire fixation and IMF. Six of the patients had an anterior open bite. The anterior maxillary downward movement was 0.1 mm±1.8, the posterior maxillary upward movement was 2.0 mm±1.3, S-N-A decreased 1.0°±1.8 and S-N-B decreased 1.2°±1.6 after a mean 8 month follow up. Overall stability was said to be good with minimal tendency to moderate relapse, however, in the present study postoperative changes at corresponding variables were even less in an equivalent early postsurgical period. Iannetti et al. found that the maxilla underwent more vertical and sagittal displacements 12-18 months after bimaxillary osteotomies than after Le Fort I osteotomy only. In both groups wire osteosynthesis was used. In the present study anterior maxillary downward movement was greater in the bimaxillary group, probably because of less initial upward movement, as seen following an isolated Le Fort I osteotomy. Turvey et al. confirmed posterior and inferior rotation of the maxillomandibular complex following bimaxillary osteotomy using wire fixation, during the first year postoperatively. Iannetti et al. reported a five-year follow up of Le Fort I osteotomies. They found no differences in a comparison between isolated Le Fort I osteotomies and bimaxillary osteotomies in the 15-60-month time interval. In the present study, however, continuous downward movement of the maxilla and extrusion of maxillary mo-
Table 12. Mean changes of dento-alveolar measurements after Le Fort I osteotomy versus bimaxillary osteotomy

<table>
<thead>
<tr>
<th>Time intervals</th>
<th>T1-T2</th>
<th>T2-T3</th>
<th>T3-T4</th>
<th>T4-T5</th>
<th>T5-T6</th>
</tr>
</thead>
<tbody>
<tr>
<td>segments (n)</td>
<td>mean</td>
<td>mean</td>
<td>SD</td>
<td>P</td>
<td>mean</td>
</tr>
<tr>
<td>+1-PP (°)</td>
<td>-1.74</td>
<td>-2.17</td>
<td>6.20</td>
<td>NS</td>
<td>-0.68</td>
</tr>
<tr>
<td>-1-MP (°)</td>
<td>1.64</td>
<td>-0.85</td>
<td>5.98</td>
<td>*</td>
<td>1.85</td>
</tr>
<tr>
<td>-1-+1 (°)</td>
<td>0.11</td>
<td>2.86</td>
<td>9.50</td>
<td>NS</td>
<td>8.10</td>
</tr>
<tr>
<td>overbite (mm)</td>
<td>0.47</td>
<td>0.14</td>
<td>1.61</td>
<td>NS</td>
<td>4.04</td>
</tr>
<tr>
<td>overjet (mm)</td>
<td>-1.55</td>
<td>-0.57</td>
<td>2.50</td>
<td>NS</td>
<td>-3.23</td>
</tr>
</tbody>
</table>

NS: Not significant. *: P<0.05. **: P<0.01. I: Le Fort I osteotomy. B: Bimaxillary osteotomy.

Table 13. Mean changes of dento-alveolar measurements after a one-piece versus multi-segment Le Fort I osteotomy

<table>
<thead>
<tr>
<th>Time intervals</th>
<th>one-</th>
<th>multi-</th>
<th>one-</th>
<th>multi-</th>
<th>one-</th>
<th>multi-</th>
<th>one-</th>
<th>multi-</th>
</tr>
</thead>
<tbody>
<tr>
<td>segments (n)</td>
<td>mean</td>
<td>mean</td>
<td>SD</td>
<td>P</td>
<td>mean</td>
<td>mean</td>
<td>SD</td>
<td>P</td>
</tr>
<tr>
<td>+1-PP (°)</td>
<td>-2.58</td>
<td>-1.00</td>
<td>6.20</td>
<td>NS</td>
<td>0.28</td>
<td>-3.37</td>
<td>4.67</td>
<td>**</td>
</tr>
<tr>
<td>-1-MP (°)</td>
<td>0.61</td>
<td>0.40</td>
<td>5.98</td>
<td>NS</td>
<td>1.90</td>
<td>2.32</td>
<td>4.77</td>
<td>NS</td>
</tr>
<tr>
<td>+1+1 (°)</td>
<td>0.93</td>
<td>0.52</td>
<td>9.50</td>
<td>NS</td>
<td>7.02</td>
<td>8.89</td>
<td>6.10</td>
<td>NS</td>
</tr>
<tr>
<td>overbite (mm)</td>
<td>0.32</td>
<td>0.31</td>
<td>1.61</td>
<td>NS</td>
<td>2.87</td>
<td>3.56</td>
<td>2.25</td>
<td>NS</td>
</tr>
<tr>
<td>overjet (mm)</td>
<td>-1.49</td>
<td>-0.57</td>
<td>2.50</td>
<td>NS</td>
<td>-4.60</td>
<td>-5.36</td>
<td>2.64</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS: Not significant. *: P<0.05. **: P<0.01.

Table 14. Mean changes in dento-alveolar measurements after Le Fort I osteotomy with intraosseous wire fixation versus rigid internal fixation

<table>
<thead>
<tr>
<th>Time intervals</th>
<th>WF</th>
<th>RF</th>
<th>WF</th>
<th>RF</th>
<th>WF</th>
<th>RF</th>
<th>WF</th>
<th>RF</th>
</tr>
</thead>
<tbody>
<tr>
<td>fixations (n)</td>
<td>mean</td>
<td>mean</td>
<td>SD</td>
<td>P</td>
<td>mean</td>
<td>mean</td>
<td>SD</td>
<td>P</td>
</tr>
<tr>
<td>+1-PP (°)</td>
<td>-2.46</td>
<td>-1.21</td>
<td>6.20</td>
<td>NS</td>
<td>-0.65</td>
<td>-1.22</td>
<td>4.67</td>
<td>NS</td>
</tr>
<tr>
<td>-1-MP (°)</td>
<td>-0.34</td>
<td>1.69</td>
<td>5.98</td>
<td>*</td>
<td>1.88</td>
<td>2.25</td>
<td>4.77</td>
<td>NS</td>
</tr>
<tr>
<td>-1+1 (°)</td>
<td>2.65</td>
<td>-0.40</td>
<td>9.50</td>
<td>NS</td>
<td>7.63</td>
<td>7.66</td>
<td>6.10</td>
<td>NS</td>
</tr>
<tr>
<td>overbite (mm)</td>
<td>0.58</td>
<td>-0.03</td>
<td>1.61</td>
<td>*</td>
<td>3.03</td>
<td>3.19</td>
<td>2.25</td>
<td>NS</td>
</tr>
<tr>
<td>overjet (mm)</td>
<td>-0.96</td>
<td>-1.32</td>
<td>2.50</td>
<td>NS</td>
<td>-5.16</td>
<td>-4.42</td>
<td>2.64</td>
<td>*</td>
</tr>
</tbody>
</table>

NS: Not significant. *: P<0.05. WF: Wire fixation. RF: Rigid fixation.
lars was significantly more in the bi-
maxillary group than in the Le Fort I
group in the late postoperative period.
Differences of vertical maxillary move-
ments between Le Fort I osteotomies
and bimaxillary osteotomies were pre-
dominantly caused by dental extrusion.
The compressive forces as generated by
the muscles of mastication are expected
to be lower after bimaxillary osteo-
tomies and, therefore, may have less in-
fluence on maxillary and dento-alveolar
movements. Accordingly, our findings
do not support the idea of less maxil-
lary stability if a mandibular ramus
osteotomy is performed concomi-
taneously.

The position of the mandible after a
bimaxillary osteotomy is determined by
maxillary, mandibular and condylar
changes (Fig. 3, 4). Condylar changes
are beyond the scope of this paper, and
they will be reported elsewhere. Down-
ward maxillary movements, extrusion of
teeth and movements at the mandibular
osteotomy sites resulted in an overall S-
N-B reduction of 1.74°. Relapse at the
mandibular osteotomy site is not poss-
ible when only a Le Fort I osteotomy is
performed. Skeletal and dento-alveolar
changes in the maxilla resulted in a
clockwise rotation of the mandible and a
S-N-B reduction of 0.69°.

Satrom et al.38 reported adequate
antero-posterior maxillary stability fol-
lowing Le Fort I intrusion osteotomy
and mandibular advancement by BSSO
using wire fixation or rigid fixation in
patients with maxillary hyperplasia.
The findings in our study were compar-
able with these results, but were even
better than those reported by Turvey et
al.45 and Hennes et al.19, who used,
respectively, intraosseous wire osteo-
syntheses and rigid internal fixation.
However, the superiority of rigid
fixation in vertical maxillary move-
ments after bimaxillary surgery, found
by Hennes et al.19 was neither con-
firmed by Satrom et al.38, nor by our
findings in an equivalent early post-
operative period.

Previous studies have suggested that
the improved stability after bimaxillary
osteotomies is largely due to the use of
mandibular rigid internal fixa-
tion15,19,38. Mandibular relapse in bi-
maxillary osteotomies with wire fixa-
tion has been reported as 18% by
Brammer et al.6, and 20% by Turvey et
al.45 When rigid fixation is used, greater
mandibular stability is achieved15,25.
Hennes et al.19 and Satrom et al.38 re-
ported respectively 1% and 6% relapse.
These percentages are comparable with
8% relapse after isolated sagittal split
advancement osteotomies with rigid
fixation in non-open bite patients, as re-
ported by Van Sickels et al.46 In our
study less posterior movement and
clockwise rotation of the mandible was
found in the early postoperative period
when rigid internal fixation was per-
formed. These differences between the
two groups faded out in the late post-
operative period.

Position of incisors
Skeletal and dento-alveolar instability
did not result in more relapse of over-
bite and overjet, probably due to com-
ensatory mechanisms. In patients who
underwent bimaxillary osteotomies, the
mandible showed an antero-posterior
relapse and clockwise rotation. These
mandibular changes resulted in an in-
crease of overjet. However, overbite was
preserved by anterior maxillary ex-
trusive movement.

In patients who underwent segmen-
tation of the maxilla, extrusion of
maxillary molars was noticed in the late
postoperative period. However, those
changes neither resulted in an increased
overjet nor in a decreased overbite.
When internal wire fixation was used
during surgery, the mandible showed an
antero-posterior relapse with clockwise
rotation and resulted in increased over-
jet. The posterior and anterior maxil-
lary downward movements and dental
extrusion were greater in the wire fixa-
tion group, and thus overbite was not
significantly different in this group as
compared to the rigid fixation group.
Dento-alveolar changes of mandibular
and maxillary incisors in the sagittal
plane can directly influence the interin-
ternal relationship. The position of in-
cisors is initially influenced by the
orthodontic treatment and later by soft
tissues24,27. The maxillary incisors were
orthodontically retracted presurgically
but relapsed postsurgically. The man-

---

![Fig. 4. Cephalometric analysis preoperatively, immediately postoperatively and 5 1/2 years post-
operatively of patient in Fig. 3. Contact between opposing central incisors was achieved im-
mediately postoperatively. During the follow-up period, maxillary dento-alveolar posterior
extrusion and protrusion of maxillary incisors was noticed on head plates. A clockwise ro-
tation of the mandible and backward movement due to unilateral condylar resorption resulted
in increase of overjet and decrease of overbite.](image-url)
dibular incisors were presurgically protruded but remained stable afterwards. These findings are consistent with observations by McCANCE et al., who have reported good stability of mandibular incisors, but protrusion of maxillary incisors at the one-year stage.

Skeletal and dental stability are important but are only a part of the successful treatment. In the evaluation of postsurgical clinical results after bimaxillary osteotomies, TURVEY et al. assessed facial appearance, overbite and overjet. Negative clinical results were statistically significantly associated with open bite, however, no significant relationship was found with cephalometric stability. Treatment results cannot be assessed only clinically, because vertical overbite does not reflect skeletal and dento-alveolar instability.

Divergent definitions of relapse related to immediate postoperative overbite are used in various publications. Relapse of open bite, i.e. loss of positive overbite, in 19% of the patients is generally in agreement with findings of other authors. The cause of skeletal and dento-alveolar relapse is multifactorial and the interplay between different factors can vary from one patient to another. Overcorrection of the anterior overbite by opening the posterior occlusion, might be advisable when planning a Le Fort I intrusion, and posterior tilting for closure of the anterior open bite. A coordinated surgical-orthodontic approach is essential to achieve optimal aesthetic and functional results.

Conclusions

From the present study, it can be concluded that:

1. Patients with anterior open bites treated with a Le Fort I intrusion osteotomy with or without BSSO usually exhibit good skeletal maxillary stability.
2. Patients with open bite deformities are not more prone to skeletal maxillary instability after Le Fort I intrusion osteotomies, as compared to patients with other dentoalveolar deformities.
3. Orthodontic treatment and additionally performed genioplasty had no significant effects, and segmentation of the maxilla in the Le Fort I osteotomy had minor effects on maxillary stability.
4. Internal plate fixation rendered better maxillary stability than intrasosseous wire fixation, however, results in the early postoperative period were masked by initial superior movement, when using wire fixation.
5. Vertical stability of the maxilla was better after Le Fort I intrusion osteotomy only, than after a bimaxillary osteotomy.
6. Mandibular stability in bimaxillary procedures was better in the early postoperative stage, when rigid fixation was performed.
7. Dento-alveolar changes were still present in the long term, but did not reflect skeletal instability.

References

25. KREEKKANOV LV, LITLA J, RINGQUIST M. Simultaneous correction of maxillary and mandibular dentoalveolar deformities without the use of postoperative inter-


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