Stability of sagittal split ramus osteotomy used to correct Class III maloclusion: Review of the literature

Setback of the mandible to correct mandibular prognathism is a well-known procedure. The 2 most frequently used techniques are the intraoral vertical ramus osteotomy (IVRO) and the sagittal split ramus osteotomy (SSRO). Although SSRO has been performed for many years, few data exist concerning long-term skeletal stability, and different hypotheses have been suggested to explain potential relapse. The literature published between 1985 and the present concerning this procedure was reviewed, and the authors analyze and discuss skeletal stability and factors contributing to relapse. (Int J Adult Orthod Orthognath Surg 2001;16:121–129)

While considerable data have been published regarding stability after mandibular advancement, comparatively few articles have addressed postoperative stability after mandibular setback. The lack of data until 1985 about the long-term stability of mandibular setback is reflected in a previous review by Welch,1 where only 3 studies were reported concerning the skeletal stability of this procedure.2–4 The conclusion of Welch was that mandibular setback tends to be a relatively stable operation, and it seems to be the only procedure in which rigid fixation may not play a necessary role. More recently Van Sickels and Richardson,5 in their review of rigid fixation, seem to confirm the observation of Welch, since mandibular setback was not included among the skeletal movements reviewed. Since the introduction of the mandibular sagittal split ramus osteotomy (SSRO) by Trauner and Obwegeser6 in 1957, it has become one of the most popular operations for correction of mandibular prognathism.

Recently Wolford7 discussed indications and advantages of the bilateral sagittal split osteotomy (BSSO) versus the intraoral vertical ramus osteotomy (IVRO). The main advantages are related to the rigid internal fixation (RIF) that is possible with BSSO versus IVRO, where maxillomandibular fixation (MMF) is usually required. In addition, with BSSO, repositioning of the mandible can be done first in bimaxillary surgery, and temporomandibular joint (TMJ) surgery can be performed simultaneously. Contraindications for the BSSO are as follows: (1) the presence of unerupted mandibular second molars, (2) a severely narrow anteroposterior or mediolateral dimension of the ramus with no medullary bone between the cortices, and (3) severe mandibular asymmetry. Disadvantages of the technique are related to an immediate postsurgical shift of the occlusion, if the condyle is not properly seated in the fossa when RIF is used, and an increased risk of inferior alveolar nerve injury. Wolford et al pointed out that specific surgical modifications are required to minimize this complication.8,9

The purpose of this study is to review the literature concerning the stability of BSSO to analyze the skeletal relapse found and the factors contributing to relapse.
Factors influencing stability and surgical techniques developed to prevent relapse

In their hierarchy of stability in orthognathic surgery, Proffit et al. classified isolated mandibular setback as an unstable movement, despite the long experience with this procedure. They also pointed out that postsurgical change after combined mandibular setback and maxillary advancement is similar to, and no greater than, the changes seen in each jaw after maxillary advancement or mandibular setback alone.

Wolford indicated that the relapse observed in literature may be attributable to a few identifiable and avoidable factors:

1. Unstable presurgical orthodontics
2. The condyle being forced posteriorly in the fossa, resulting in immediate relapse
3. Positioning the proximal segment by pushing posteriorly on its anterior edge, thus displacing the condyle posteriorly and downward along the posterior wall of the fossa and resulting in immediate postsurgical forward relapse with anterior open bite
4. Use of occlusal splints that open the bite and then create an upward and forward rotation of the mandible after splint removal
5. Impingement of the pterygomasseteric sling
6. Failure to remove bony interferences from the proximal segments that will not allow the segments to fit passively together
7. Macroglossia, causing dentoalveolar protrusion
8. Vertical instability of the maxilla in bimaxillary surgery, causing upward and forward rotation of the mandible
9. Untreated active condylar hyperplasia

Unfortunately, the factors indicated by Wolford have not always been analyzed in the studies reviewed. For this reason we tried to isolate patients according to the surgical procedures performed and to discuss factors that have been indicated as the more probable causes of forward movement of the mandible after surgery.

The patients reported in the studies reviewed can be divided according to the surgical procedures performed:

- Isolated mandibular setback
- Combined mandibular setback and maxillary advancement
- Rigid internal fixation
- Conventional wire (maxillomandibular) fixation

Isolated mandibular setback

The results of isolated mandibular setback, independent of fixation, are reported in Table 1. The mean values obtained have been evaluated according to the number of patients in the sample of each study reviewed. All the studies showed a tendency to relapse, with a mean relapse of 1.49 mm (22.6%) of surgical setback.

Combined mandibular setback and maxillary advancement

The results of combined mandibular setback and maxillary advancement are shown in Table 2. Only 3 studies were published concerning the stability of mandibular setback in bimaxillary surgery for correction of Class III deformities. Only 2 studies had a consistent sample of patients, and in both these studies, a correlation between the amount of clockwise rotation of the proximal segment and relapse was observed. The mean mandibular setback was 5.44 mm, with a mean relapse of 3.33 mm (61.2%).

Rigid internal fixation

The results of mandibular setback stabilized with rigid fixation in single- or double-jaw surgery are reported in Table 3. The mean amount of surgical setback was 6.28 mm. Reported relapse rates varied from 9.8% to 62%, with a mean value of 23.9%.

Wire osteosynthesis

The results of mandibular setback stabilized with wire osteosynthesis are reported in Table 4. The mean amount of surgical setback was 7.11 mm, with a mean relapse of 1.63 mm (22.9%).
Table 1  Results of isolated mandibular setback

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. of patients</th>
<th>Mean setback (mm)</th>
<th>Mean relapse (mm)</th>
<th>% relapse</th>
<th>% of patients with relapse &gt; 2 mm</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phillips et al 1986</td>
<td>19</td>
<td>5.4</td>
<td>2.1</td>
<td>38.9</td>
<td>47</td>
<td>The amount of surgical setback was correlated to relapse.</td>
</tr>
<tr>
<td>Kobayashi et al 1986</td>
<td>44</td>
<td>8.4</td>
<td>0.6</td>
<td>7.1</td>
<td>16</td>
<td>The magnitude of relapse was proportional to that of the correction in the horizontal direction ($P &lt; .01$).</td>
</tr>
<tr>
<td>Krekmanov et al 1989</td>
<td>14</td>
<td>6.3</td>
<td>0.8</td>
<td>12.7</td>
<td>7</td>
<td>Conclusion recommends the use of RIF.</td>
</tr>
<tr>
<td>Franco et al 1989</td>
<td>14</td>
<td>4.87</td>
<td>2.13</td>
<td>43.7</td>
<td>NR</td>
<td>The magnitude of setback was the single variable that accounted for relapse with single-jaw surgery.</td>
</tr>
<tr>
<td>Sorokolit and Nanda 1990</td>
<td>25</td>
<td>5.1</td>
<td>0.5</td>
<td>9.8</td>
<td>8</td>
<td>There is no relationship between the amount of surgical movement and the amount of relapse.</td>
</tr>
<tr>
<td>Proffit et al 1991</td>
<td>40</td>
<td>5.58</td>
<td>2.87</td>
<td>51.4</td>
<td>60</td>
<td>In BSSO patients, the chin is likely to move forward postsurgically, and the surgical technique used should be altered to reduce forceful seating of the condyles and posterior movement of the ramus segment.</td>
</tr>
<tr>
<td>Schatz and Tsimas 1995</td>
<td>13</td>
<td>7.27</td>
<td>2.85</td>
<td>39.2</td>
<td>NR</td>
<td>Statistically significant differences in horizontal measurements indicated a relapse tendency.</td>
</tr>
<tr>
<td>Ingervall et al 1995</td>
<td>29</td>
<td>6.0</td>
<td>1.3</td>
<td>21.7</td>
<td>28</td>
<td>Relapse tended to be large in patients who underwent a large posterior displacement at surgery.</td>
</tr>
<tr>
<td>Rodríguez and González 1996</td>
<td>14</td>
<td>8.75</td>
<td>2.23</td>
<td>25.5</td>
<td>50</td>
<td>This study demonstrated that skeletal relapse was influenced by the magnitude of surgical correction.</td>
</tr>
<tr>
<td>Harda and Enomoto 1997</td>
<td>20</td>
<td>6.65</td>
<td>1.22</td>
<td>18.3</td>
<td>NR</td>
<td>Conclusions regard comparison between poly-l-lactic acid and titanium screws.</td>
</tr>
<tr>
<td>Mobarak et al 2000</td>
<td>80</td>
<td>6.93</td>
<td>1.27</td>
<td>18.3</td>
<td>36</td>
<td>The magnitude of mandibular setback was found to be weakly associated with the amount of horizontal relapse, while clockwise rotation of the ascending ramus at surgery contributes to early horizontal relapse but does not seem to be responsible for marked relapse.</td>
</tr>
</tbody>
</table>

Total/means: 312 (28) 6.59 1.49 22.6 33

NR = not reported.
Discussion

With regard to the large individual variation in postsurgical response, it should be emphasized that reporting mean changes only may be misleading, and it would be more useful to report percentages of patients with changes large enough to be clinically significant. Proffit et al.\(^{16}\) reported a change of 2.0 mm as a cutoff value at which postoperative changes begin to be difficult to correct with postoperative orthodontic treatment and therefore clinically significant. Unfortunately, not all the studies reviewed had data of the sample organized so as to understand percentage of patients with clinically significant changes of mandibular landmarks.

Isolated mandibular procedure

Despite the recent increase in the percentage of Class III patients given maxillary or bimaxillary procedures,\(^{24}\) isolated mandibular setbacks continue to be the procedure of choice in many cases with true mandibular prognathism.

In the studies reviewed, the mean mandibular setback at surgery for isolated mandibular procedures (6.59 mm) was greater than that observed in bimaxillary surgery (5.04 mm) as a logical consequence of the entire correction of the skeletal malocclusion with mandibular surgery. Skeletal relapse ranges from 7.1% to 51.4%, with a mean value of 22.6%, emphasize that despite the long experience with this procedure, existing scientific evidence still conflicts regarding its long-term stability. One third of the patients (33%) in the sample of studies in which clinically significant relapse has been reported exhibited relapse of 2 mm or more. Many authors found that the most important factor accounting for relapse was the magnitude of surgical movement,\(^{12,14,18,19}\) while others did not find this correlation.\(^{15}\) Phillips et al.\(^{11}\) observed less change in the region of the mandibular angle with BSSO in comparison with transoral vertical ramus osteotomy, but observed a greater amount of relapse at B point. The amount of surgical setback was correlated with relapse in both procedures, but TOVRO had greater stability for mandibular setback of less than 5.0 mm. Kobayashi et al.\(^{12}\) found a significant relationship between setback and relapse, particularly when the amount of setback exceeds 10 mm.

Of great interest in our opinion is the work of Franco et al.\(^{14}\) Although their sample was only 14 patients and the authors

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. of patients</th>
<th>Mean setback (mm)</th>
<th>Mean relapse (mm)</th>
<th>% relapse</th>
<th>% of patients with relapse &gt; 2 mm</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Franco et al 1989(^{14})</td>
<td>11</td>
<td>5.43</td>
<td>2.9</td>
<td>53.4</td>
<td>NR</td>
<td>Alteration of the proximal segment position accounts for relapse in bimaxillary surgery.</td>
</tr>
<tr>
<td>Law et al 1989(^{22})</td>
<td>3</td>
<td>4.5</td>
<td>0.7</td>
<td>15.5</td>
<td>NR</td>
<td>No conclusion was reported.</td>
</tr>
<tr>
<td>Proffit et al 1991(^{23})</td>
<td>51</td>
<td>5.5</td>
<td>3.58</td>
<td>71.6</td>
<td>70.6</td>
<td>For long face Class III patients, stability of the mandible was better in bimaxillary surgery than with mandibular setback alone. For patients with minimal vertical change, the moderate relapse tendency of the mandible was correlated with posterior movement of gonial angle. For short face patients in whom the maxilla must be moved down, two thirds had point B move forward more than 4 mm.</td>
</tr>
<tr>
<td>Totals/means</td>
<td>65 (21.66)</td>
<td>5.44</td>
<td>3.33</td>
<td>61.2</td>
<td>70.6</td>
<td></td>
</tr>
</tbody>
</table>

NR = not reported.
did not report the percentage of patients with significant relapse, the surgical technique was consistent, and comparison with the stability of mandibular setback in bimaxillary surgery was made. Correlation was found between the amount of surgical setback and relapse in single-jaw surgery, while such a correlation was not found in bimaxillary cases.

In line with results reported by Franco et al.\textsuperscript{14} is the work of Ingervall et al.\textsuperscript{18} and Rodríguez and González.\textsuperscript{19} Ingervall et al.\textsuperscript{18} also emphasized that the technique used by the individual surgeon in setting the condylar segment is probably of importance for the stability of the BSSO with RIF.

### Table 3: Results of mandibular setback stabilized with rigid internal fixation

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. of patients</th>
<th>Mean setback (mm)</th>
<th>Mean relapse (mm)</th>
<th>% of patients with relapse &gt; 2 mm</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Krekmanov et al 1989\textsuperscript{13}</td>
<td>14</td>
<td>6.3</td>
<td>0.8</td>
<td>12.7</td>
<td>RIF improved stability between the segments, reduced postoperative relapse, and reduced use of maxillomandibular fixation.</td>
</tr>
<tr>
<td>Franco et al 1989\textsuperscript{14}</td>
<td>25</td>
<td>5.11</td>
<td>2.46</td>
<td>48.1</td>
<td>As in cases treated with wire osteosynthesis, even when rigid fixation is used with mandibular set-backs, postoperatively the mandible moves forward.</td>
</tr>
<tr>
<td>Sorokolit and Nanda 1990\textsuperscript{15}</td>
<td>25</td>
<td>5.1</td>
<td>0.5</td>
<td>9.8</td>
<td>The study indicates that mandibular setback with BSSO and RIF appears to be a fairly stable clinical procedure.</td>
</tr>
<tr>
<td>Proffit et al 1991\textsuperscript{16}</td>
<td>11</td>
<td>5.8</td>
<td>3.6</td>
<td>62</td>
<td>There was a relapse tendency that was greater in the RIF group than the wire fixation group. About half the total forward positioning of the mandible during the first year occurred during the first 6 weeks, soon after function resumed.</td>
</tr>
<tr>
<td>Schatz and Tsimas 1995\textsuperscript{17}</td>
<td>13</td>
<td>7.27</td>
<td>2.85</td>
<td>39.2</td>
<td>BSSO with RIF is prone to significant relapse. The surgeon may tend to seat the condyles too far posteriorly and, as RIF maintains the proximal segment in an upright position, the postsurgical changes are expressed horizontally, without the local adaptation at the osteotomy site that would be possible with wire osteosynthesis.</td>
</tr>
<tr>
<td>Ingervall et al 1995\textsuperscript{18}</td>
<td>29</td>
<td>6</td>
<td>1.3</td>
<td>21.7</td>
<td>The technique used by the individual surgeon in setting the condylar segment is probably of importance for the stability of the BSSO with RIF.</td>
</tr>
<tr>
<td>Harada and Enomoto 1997\textsuperscript{19}</td>
<td>20</td>
<td>6.65</td>
<td>1.22</td>
<td>18.3</td>
<td>Fixation of the bony segments with poly-l-lactic acid screws after BSSO may be used effectively in properly selected cases.</td>
</tr>
<tr>
<td>Mobarak et al 2000\textsuperscript{20}</td>
<td>80</td>
<td>6.93</td>
<td>1.37</td>
<td>18.3</td>
<td>BSSO with rigid fixation for mandibular setback appears to be a fairly stable clinical procedure. Most of the relapse took place during the first 6 months after surgery.</td>
</tr>
</tbody>
</table>

Totals/means: 217 (27.1) 6.28 1.5 23.9 30.8

NR = not reported.
Proffit et al. observed a strong tendency toward relapse and related it to clockwise rotation of the ramus segment at surgery. The same observation, although with less relapse, was made by Schatz and Tsimas. Recently, Mobarak et al. reported good stability 3 years postoperatively with a larger sample (80 patients). They also found a correlation between surgical setback and relapse, while clockwise rotation of the ascending ramus contributed to relapse mostly during the first 6 months after surgery.

In conclusion, the majority of the authors indicated the magnitude of surgical setback as the most important factor influencing long-term stability, while others found a correlation between relapse and surgical clockwise rotation of the ramus segment with altered condylar position.

**Combined maxillary advancement and mandibular setback**

Considering the fact that after 1985 the number of patients undergoing combined maxillary and mandibular surgery for correction of Class III skeletal relationship increased, it is rather surprising that only 3 studies have been published in literature concerning the stability of BSSO for mandibular setback in bimaxillary surgery. Moreover, only 2 of these works had a consistent sample of patients to be discussed.

The mean surgical setback was 5.44 mm, with a mean relapse of 3.33 mm (61.2% of surgical movement). The values obtained have to be considered critically in relation to the few studies reported. Both studies with a consistent sample—Franco et al. and Proffit et al.—found a correlation between relapse and alteration of the proximal segment position during surgery.

Proffit et al. found that the magnitude of setback had little influence in proximal segment in single-jaw cases, but had more influence with double-jaw procedures. They supposed that when one repositions the distal segment posteriorly, the medial and lateral attachments are placed under tension, resulting in a tendency for the mandible to relapse. Although steps were taken to prevent clockwise rotation of the proximal segment in both their single-jaw and double-jaw cases, the mandible was set back more in bimaxillary cases. The authors concluded that the more the mandible was set back, the greater the tendency to rotate the proximal segment. We

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. of patients</th>
<th>Mean setback (mm)</th>
<th>Mean relapse (mm)</th>
<th>% of patients with relapse &gt; 2 mm</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phillips et al 1986</td>
<td>19</td>
<td>5.4</td>
<td>2.1</td>
<td>38.9</td>
<td>The BSSO group showed significantly greater relapse in the SNB angle and more anterior movement of B point than the TOVRO group.</td>
</tr>
<tr>
<td>Kobayashi et al 1986</td>
<td>44</td>
<td>8.4</td>
<td>0.6</td>
<td>7.1</td>
<td>Although no single parameter is responsible for the development of relapse, significant relapsing potential may exist when the amount of correction exceeds 10 mm.</td>
</tr>
<tr>
<td>Proffit et al 1991</td>
<td>29</td>
<td>5.5</td>
<td>2.6</td>
<td>47.3</td>
<td>The ramus position can adjust itself postsurgically via movement at the osteotomy site if wire osteosynthesis is used.</td>
</tr>
<tr>
<td>Rodríguez and González 1996</td>
<td>14</td>
<td>8.75</td>
<td>2.23</td>
<td>25.5</td>
<td>Skeletal relapse was evident after removal of MMF and was influenced by the magnitude of surgical correction.</td>
</tr>
<tr>
<td>Totals/means</td>
<td>106 (26.5)</td>
<td>7.11</td>
<td>1.63</td>
<td>22.9</td>
<td>35.8</td>
</tr>
</tbody>
</table>
do not agree completely with this conclusion, because if magnitude of setback and clockwise rotation of the proximal segment are in fact correlated, as they supposed, they should have found a correlation of both the variables (magnitude of setback and clockwise rotation) with relapse in the bimaxillary group. Proffit et al23 observed this correlation particularly when minimal vertical changes were performed at the maxilla. Mandibular stability for long face patients with maxillary superior repositioning was better than with mandibular setback alone, and patients with short face and maxillary inferior repositioning had the worst mandibular stability.

Mandibular setback stabilized with rigid fixation

Results of BSSO stabilized with rigid fixation, independent of the number of jaws mobilized for correction of skeletal relationships, indicated a mean relapse of 24% of surgical setback, which is even greater than that reported for wire osteosynthesis. Approximately one third of the patients (30.8%) showed clinically significant relapse.

While some authors considered BSSO with rigid fixation a stable procedure,13,15,21 others found this procedure prone to significant relapse.14,16,17 Franco et al14 reported a clockwise proximal segment rotation at surgery with subsequent relapse in ramus inclination representing about 72% of the rotation performed at surgery. The authors found the tendency for greater relapse to be correlated with increasing intraoperative proximal segment rotation for bimaxillary surgery but not for their single-jaw mandibular setback cases. The study of Proffit et al16 reported similar observations, and it is the only study with a sample of patients that makes a comparison between rigid and wire fixation. They observed a strong relapse tendency attributed to excessive posterior rotation of the proximal segment, which stretched the medial and lateral muscular attachments. The stretched mandibular musculature tends to return the ramus to its original inclination when function resumes, resulting in forward movement of the chin. This tendency was even more pronounced when rigid fixation was used, because the local adaptation at the osteotomy site, which would have been possible if wire osteosynthesis were used, does not take place. Schatz and Tsimas17 reported the same observation of Proffit et al,16 although with less relapse, and both concluded that technical refinements should be investigated to improve the stability of BSSO for mandibular setback.

More recently, Mobarak et al21 analyzed a more consistent sample of patients and concluded that the relapse tendency cannot be attributed solely to intraoperative proximal segment rotation. They also observed a tendency of the proximal segment to return to its original inclination and related this reorientation of the ascending ramus to most of the relapse (72%) that took place during the first 6 months after surgery; however, they concluded that it did not seem to be responsible for marked relapse. They proposed the use of Class III elastics extended to the first 6 months to fine-tune the occlusion while skeletal equilibrium is being reestablished.

Mandibular setback stabilized with wire osteosynthesis

Stability of BSSO with wire osteosynthesis appears to be similar to and even better than that reported for rigid fixation. Reviewing the literature, we found a greater mean mandibular setback (7.11 mm versus 6.28 mm) and a lower mean percentage of relapse (23% versus 24%) for wire osteosynthesis, in comparison with rigid fixation studies. Percentages of patients with significant relapse of 2 mm or more are superior to but not very different from that reported for RIF (35.8% versus 30.8%). Even considering the relatively small number of studies published with this technique in comparison to those stabilized with rigid fixation, a possible explanation of the relatively better stability observed with wire osteosynthesis is suggested by the study of Proffit et al.16 Proffit et al16 attributed their lower percentage of relapse for the wire osteosynthesis group to the ability of the ramus to adjust itself postsurgically via movement at the osteotomy site. They reported a mean increase in the gonial angle at surgery of 3.7 degrees, with relapse 1 year later of 4.2
degrees. Relapse in ramus inclination thus represented 113% of the rotation at surgery. Even more dramatic values were observed by Phillips et al,11 who reported a mean increase in the gonial angle of 2.5 degrees, with relapse 1 year later of 4.4 degrees, or 176% of the rotation at surgery. These results show how, with wire osteosynthesis, relapse in ramus inclination is greater than the clockwise rotation at surgery, indicating a certain grade of sliding of the proximal on the distal segment of osteotomy after surgery.

Kobayashi et al12 found excellent stability in their sample, especially in relation to mandibular setback (8.4 mm). They also reported an overall relapse during the first 6 months of 0.9 mm, while from 6 months to 1 year postoperatively there was a mean posterior movement of 0.3 mm.

Conclusions

Through an analysis of the literature concerning the stability of BSSO for mandibular setback we were able to conclude the following:

• When BSSO is performed for correction of skeletal Class III malocclusion, there is a significant likelihood (approximately 30%) that a skeletal relapse will occur that will require orthodontic postoperative compensation to maintain satisfactory dental relationships.

• For isolated mandibular setback surgery, the most important factor accounting for relapse seems to be the magnitude of mandibular setback.

• At the moment it is very difficult to draw any conclusions regarding the stability of BSSO in bimaxillary surgery, due to the paucity of data published in the literature. Consequently, it is still unclear whether some Class III skeletal patterns are more stable when bimaxillary surgery is performed. Counterclockwise rotation of the proximal segment appears to be the most important factor in contributing to relapse.

• There is only one study in the last 15 years that compares the stability of BSSO for mandibular setback stabilized with rigid versus wire fixation.

• In all the studies reviewed, the mean percentage of patients with clinically significant relapse and the mean percentage of relapse indicate that rigid fixation does not seem to guarantee significantly greater stability than wire fixation. This is probably a result of the ability of the proximal segment to slide over the distal segment when wire osteosynthesis is performed, while this is not possible with RIF. For this reason, the surgeon must take special care to avoid counterclockwise rotation of the proximal segment during surgery when RIF is used.

References


