Impact and Stability of Mandibular Setback after Intraoral Vertical Ramus Osteotomy

Alex Dobriyan 1,†, Eyal Akerman 1,*†, Tal Yoffe 1, Daneilla Blinder 1, Idit Tessler 2, Nir Abraham Gecel 3, Mor Mesika 1 and Ran Yahalom 1

1 Department of Oral and Maxillofacial Surgery, Sheba Tel-Hashomer Medical Center, Ramat-Gan 52621, Israel
2 Department of Otolaryngology—Head and Neck Surgery, Sheba Tel-Hashomer Medical Center, Ramat-Gan 52621, Israel
3 Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv 6997801, Israel
* Correspondence: eyal.akerman@sheba.health.gov.il
† These authors contributed equally to this work.

Abstract: (1) Background: The purpose of this study was to evaluate stability and complications following mandibular setback using intraoral vertical ramus osteotomy (IVRO) and provide an assessment of IMF (Inter-maxillary Fixation) compliance. (2) Methods: This is a retrospective cohort study. It included a total of 39 patients who underwent 78 IVRO for the treatment of mandibular prognathism between 2005 and 2021 at Sheba Medical Center. Radiographic and clinical examinations were performed preoperatively (T0), 3 days post-surgery (T1) and 8 months post-surgery (T2). Measurements of dental and skeletal stability, as well as neurosensory disturbances and TMJ dysfunctions, were statistically analyzed. (3) Results: The mean mandibular setback was 5.6 mm. A relapse of less than 2 mm was observed at T2. A short-term neurological disturbance was reported in 38.46% of the 39 patients, and 17.94% of them showed full recovery by T2. In 21 patients who underwent IVRO without genioplasty, only 14.28% reported long-term sensory disturbance. In addition, when a vertical osteotomy was performed, neurological damage was 174% higher as compared to oblique osteotomy. The IMF compliance rate for the 6 weeks postoperatively was 100%. (4) Conclusion: IVRO is still a relevant and valid technique for the treatment of mandibular prognathism that provides stable results with minimal complications rate.

Keywords: IVRO; mandibular prognathism; mandibular setback; IMF

1. Introduction

Today there are two commonly used techniques to treat mandibular prognathism: Intraoral Vertical Ramus Osteotomy (IVRO) and Sagittal Split Ramus Osteotomy (SSRO) [1].

In 1849, Hullihen was the first to describe mandibular osteotomy; almost 50 years later, V.P. Blair used mandibular body osteotomy for the treatment of mandibular prognathism, which was used until the 1970s of the last century. In 1957, Trauner and Obwegeser first reported on SSRO, which has evolved through a number of modifications, including the transition to rigid internal fixation suggested by Spiessel [2].

The first IVRO was described by Winstanley in 1968 and refined later on by Hall and McKenna in the 1970s [1,2]. The IVRO osteotomy technique has not changed much in recent years, but different designs for the ramus osteotomy have been developed. These designs refer to the shape of the cut made on the posterior part of the ramus, such as the oblique and vertical osteotomy. Although theoretically there might be differences in the frequencies of postoperative sensory changes according to the osteotomy design, there have been no previous studies to confirm them [2,3].
Although both techniques (SSRO and IVRO) provide good stability, there is still a disagreement concerning the preferable procedure for the treatment of mandibular prognathism [4–6].

Ellis et al. performed a systematic review and meta-analysis that found that among 678 patients subdivided into two groups (SSRO N-318 and IVRO-341), there was no statistically significant difference regarding horizontal skeletal stability, but the SSRO group had more stability in the vertical dimension ($p = 0.02$) [6].

There are several advantages and disadvantages to each surgical technique. The main advantage of the IVRO is the lower prevalence of inferior alveolar nerve (IAN) damage compared to the damage created by the SSRO technique. The prevalence of immediate sensory damage in IVRO is 0–36%, while the prevalence of long-term damage is considered lower at 2.3–14% [7]. The reported risk of a long-term IAN deficit after an SSRO is highly variable and has been reported to be 0% to 75%, with an average of 33% for objective testing [8]. Moreover, in addition to the possible sensory damage to IAN, there are studies that have reported the incidence of lingual nerve (LN) dysfunction using the SSRO technique. Jacks et al. reported that 19.4% of 134 patients experienced LN sensory changes, and 69% of them reported sensory changes still present one year after the surgery [2,9]. When genioplasty is performed in addition to IVRO, and even more significantly in addition to SSRO, it increases the prevalence of sensory damage—there are several studies with different protocols that make it difficult to establish a clear connection—but even in patients that underwent only genioplasty, the prevalence for sensory damage can be as high as 20% [10–13].

Another benefit of IVRO is its ability to improve TMD symptoms due to anterior inferior movement of the condyle that reduces pressures on the articular disc and repositions the condyle in its physiologic equilibrium except for cases of condylar displacement or luxation from the glenoid fossa. On the other hand, the use of SSRO can increase TMD symptoms due to the difficulty in reproducing the proper position of the condyle [14,15].

The main disadvantage of IVRO is the need for prolonged intermaxillary fixation (IMF) that affects the patient’s quality of life in the immediate post-surgical period. This includes jaw immobility, a liquid diet that may cause weight loss, the late recovery of normal mouth-opening function, and possible periodontal damage. For those reasons and with the development of the rigid fixation that eliminates the need for IMF, the majority of oral and maxillofacial centers use SSRO as the favorable method, particularly in Europe and North America [1].

In our center, we still often perform IVRO for the treatment of mandibular prognathism. The aim of this present study was to provide an updated evaluation of dental and skeletal stability after the surgical treatment of mandibular prognathism with IVRO. In addition, we evaluated the neurosensory disorders with reference to the type of injury (anesthesia, paresthesia, dysesthesia) and possible connection to osteotomy design and additional genioplasty procedures.

Another important goal was to clarify the compliance for a prolonged period of use of IMF, considering the fact that in the common literature, there are not enough data regarding this important factor, which could influence the surgeon’s decisions on which surgical treatment is preferable for the treatment of mandibular prognathism.

2. Materials and Methods

2.1. Study Design and Patients

A retrospective cohort study was undertaken using patients’ files from the database of the Oral and Maxillofacial Surgery Department at Sheba Medical Center between the years 2005 and 2021.

Included were all patients diagnosed with mandibular prognathism and treated with IVRO surgery with subsequent IMF for 6 weeks. All included patients had documentation
of clinical and radiological preoperative, intraoperative, and postoperative examinations. Postoperative follow-up of at least 8 months was necessary for inclusion in the study.

The records of 39 patients were screened. Seventy-eight IVRO surgeries were included. It was noted that 46% of patients underwent a genioplasty procedure in addition to IVRO.

Patients’ charts were reviewed for data regarding demographics, clinical and radiological examination, including occlusion diagnosis, overbite and overjet, skeletal measurement, neurosensory deficit, as well as other symptoms such as sensitivity or noisiness in TMJ function, and maximal interincisal opening were taken at the following specific time points; preoperatively (T0), 3 days postoperatively (T1), and 8 months postoperatively (T2).

2.2. Radiographic Evaluation

The radiological examination included a panoramic radiograph and lateral cephalogram to examine the jaws relation, osteotomy design, and bone healing.

Lateral cephalometric radiographs were obtained and included the following points for the evaluation of skeletal and dental stability: sella (S), nasion (N), B-point (B), condylion (Co), incisor superior (Is), and incisor inferior (Ii).

2.3. Surgical Protocol

All of the operations were performed by two consulting Oral and Maxillofacial Surgeons. The procedure was performed under general anesthesia using nasotracheal intubation. The incision was made intraorally from the anterior border of the ramus, exposing the lateral surface of the ramus from the sigmoid notch to the mandibular angle. The osteotomy was carried from the sigmoid notch to the inferior border of the mandible. The cut was made less than 5–7 mm anterior to the posterior border of the mandible, with the purpose of considering the location of the mandibular foramen.

The design for the ramus osteotomy is referred to by the location of the bony cut made on the posterior part of the ramus. The oblique osteotomy ends posterior to the mandibular angle, while the vertical osteotomy ends anterior to the mandibular angle.

After completing the osteotomy, the proximal (posterior) fragment is always placed lateral to the distal part of the mandible. The dentition is brought to the planned position, and the patient is placed in IMF for the following 6 weeks. In some cases, the IVRO was associated with other conventional orthognathic procedures, such as a Le Fort I osteotomy (LFI) and additional genioplasty.

2.4. Independent Variable

Patients with mandibular prognathism undergoing IVRO surgery for orthognathic correction.

2.5. Dependent Variables

1. Co–B: distance between B-point (B) and condylion (Co) point (most superior posterior point on the condyle), measured in millimeters using lateral cephalogram X-ray (Figure 1).
2. SNB angle: angle between the SN (Sella—Nasion) line and the NB (Nasion—B point) line was measured in degrees using lateral cephalogram X-ray.
3. Overbite, overjet—measured in millimeters between incisor superior (Is) and incisor inferior (Ii) used as evaluation of dental stability (Figure 2).
4. TMJ functions and symptoms (joint pain, clicking sounds)—examined during the preoperative and the follow-ups.
5. Neurosensory dysfunction (anesthesia—total loss of sensation; hypoesthesia—decrease in normal sensation; dysesthesia—abnormal sensation, interpreted as a painful burning or aching feeling)—examined before surgery and during the follow-
up examinations. All of the clinical tests were performed while the patient was sitting with eyes closed. First, the patient was asked to describe any changes in the sensation over the face area, followed by a cotton swab and a pinprick test:

- Cotton swab test: Detects sensitivity to low-intensity, non-painful mechanical stimulation. The skin was gently stroked above the area of IAN innervation on both sides while comparing the response with the contralateral side. Three to four strokes, 1–2 cm in length, on both sides were performed; patients reported normal sensation on both sides (normosensitivity), less sensation on one side than the other (hyposensitivity), or total loss of sensation (anesthesia). Painful/annoying feeling was classified as dysesthesia.

- Pinprick test: A toothpick or dental explorer was applied to test sensitivity to high-intensity painful mechanical stimulation of the skin above the area of IAN innervation on both sides.

6. IMF compliance—the fixation was assembled at the end of the surgery and removed 6 weeks postoperatively.

7. Osteotomy design—the shape of the osteotomy line was evaluated with a surgery report and the post-surgical panoramic X-ray.

Figure 1. Lateral cephalometric X-ray measuring points. Abbreviations: S—Sella; N—Nasion; A—Hard tissue A point; B—Hard tissue B point; Co—Condylion.
2.6. Statistical Analysis

The categorical variables were reported using frequencies and percentages, and continuous variables using means and standard deviation. Association tests were performed using Pearson’s chi-square tests, Student’s t-tests, and Wilcoxon signed-rank test tests for categorical and continuous variables, respectively. We evaluated whether the variables were normally distributed using a Shapiro–Wilk test. We considered a two-tailed p-value of < 0.05 as significant. All analyses were performed with SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY, USA: IBM Corp.).

3. Results

The study group included 39 patients (18 females and 21 males). The mean age at surgery was 22.79 years (SD = 5.63, range 16–40). Thirty-two patients (82%) underwent bimaxillary operations that included LeFort 1 and Bilateral IVRO, while only seven patients (18%) underwent a single jaw mandibular surgery. Eighteen patients (46.1%) were treated with genioplasty in addition to bilateral VRO. The mean amount of mandibular setback was 5.64 mm (SD = 1.24). The mean postoperative follow-up period was 14.4 months (SD = 10.23).

3.1. Stability

The measurement of skeletal stability was performed by calculating the changes between the SNB angle and the distance between the Co and B points based on lateral cephalograms at T1 (3 days postoperative) and T2 (8 months postoperative). At T2, the mean SNB angle was 79.99 degrees (SD = 4.39), while at T1, the mean SNB was 81.71 degrees (SD = 3.97) with significant differences (p < 0.01). The mean distance between the Co and B points at T2 was 104.89 mm compared to 106.50 mm at T1; the changes from T1 to T2 were not statistically significant (p = 0.07), representing skeletal stability with a mean backward relapse of 1.6 mm (as presented in Table 1).

The mean overbite before surgery (T0) was −0.16 mm (SD), and the overjet was −5.76 mm (SD = 2.72). At day 3 postoperatively (T1), the mean overbite was ±1.78 mm, and overjet was 1.73 mm (SD = 0.78, SD = 0.57), with statistical significance (p < 0.01)
representing the surgical setback. At T2 (8 months postoperatively), the mean overbite was 1.8 mm (SD = 0.56), and the mean overjet was 1.60 mm. (SD = 0.78). The changes from T1 to T2 were not statistically significant for either overbite ($p = 0.19$) or overjet ($p = 0.46$), representing dental stability with a mean relapse of less than 2 mm (OB ± 0.17, OJ ± 0.06) (as presented in Table 2).

Table 1. Skeletal stability; SNB angle and Co–B measurements.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean (+SD)</th>
<th>Mean Relapse</th>
<th>$p$ Value (t-Test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 SNB (degrees)</td>
<td>39</td>
<td>81.71 + 3.97</td>
<td>1.72</td>
<td>$p &lt; 0.01$</td>
</tr>
<tr>
<td>T2 SNB (degrees)</td>
<td></td>
<td>79.99 + 4.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1 Co–B (mm)</td>
<td></td>
<td>106.15 + 9.08</td>
<td>1.60</td>
<td>0.07</td>
</tr>
<tr>
<td>T2 Co–B (mm)</td>
<td></td>
<td>104.89 + 8.16</td>
<td></td>
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</tbody>
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Table 2. Dental stability; Overjet and Overbite movements measurements.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean (+SD)</th>
<th>Mean Relapse</th>
<th>$p$ Value (t-Test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 Overjet (mm)</td>
<td>39</td>
<td>1.73 + 0.78</td>
<td>−0.06</td>
<td>0.46</td>
</tr>
<tr>
<td>T2 Overjet (mm)</td>
<td></td>
<td>1.60 + 0.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1 Overbite (mm)</td>
<td></td>
<td>1.78 + 0.78</td>
<td>0.17</td>
<td>0.19</td>
</tr>
<tr>
<td>T2 Overbite (mm)</td>
<td></td>
<td>1.8 + 0.56</td>
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3.2. Neurosensory Disturbances

All of the patients were examined for neurosensory disturbance before surgery (T0) and during the postoperative follow-ups (T1, T2). Immediate neurosensory disturbance at T1 was found in 15 patients (38.46%). At T2, 17.94% of the patients with an immediate neurosensory disturbance reported full recovery, while 20.51% remained with sensory disturbance.

As previously described, we classified long-term neurosensory disturbance into three categories: hypoesthesia, dysesthesia, and anesthesia. Hypoesthesia was found in three patients (7.69%), dysesthesia in four patients (10.25%), and anesthesia was found only in one patient (2.56%).

Of all 39 patients, 18 were treated with genioplasty in addition to bilateral IVRO. In the genioplasty group, 55.6% (ten patients) reported short-term sensory disturbance compared to 23.8% (five patients) that had been treated with IVRO only. Long-term sensory disturbance was significantly higher at 27.77% of the 18 patients that had additional genioplasty compared to 14.28% of the 21 patients that were treated with IVRO only. The difference in the prevalence of neurosensory disturbance between the groups of patients that were treated with genioplasty and IVRO compared to IVRO only was statistically significant in the short term ($p = 0.04$), while in the long term, there was no significant difference between the two groups ($p = 0.29$).

Of all 78 ramus osteotomies, 53.84% had an oblique osteotomy design, while 46.15% underwent a vertical-type osteotomy. In 16.67% of the procedures that included a vertical osteotomy design, a long-term neurosensory disturbance was reported, compared to only 9.52% of the cases that had oblique osteotomy. No statistically significant correlation was found between the osteotomy design and the neurosensory disturbance ($p = 0.34$).

3.3. IMF Compliance

The IMF compliance rate during the 6 week period following the surgery was 100%.
3.4. TMJ Dysfunction

Before surgery at T0, 23.07% of the patients reported at least one symptom regarding TMJ, as opposed to only 15.38% at T2. However, the difference from T0 to T2 was not found to be statistically significant ($p = 0.08$).

Maximal mouth opening (MMO) at T0 had a mean of 50 mm (SD = 7.17), while at T2, the mean MMO decreased to 44.47 mm (SD = 4.81), which was found to be statistically significant ($p < 0.01$).

4. Discussion

IVRO surgery used to be a common technique to treat mandibular prognathism in Western medicine. This technique has changed throughout the years in order to simplify the procedure for the surgeon and reach a stable result with a lower rate of complications. The aim of this study was to provide an updated evaluation of the dental and skeletal stability using IVRO for the treatment of mandibular prognathism, evaluate the postoperative complication such as neurosensory disorders with reference to the type of injury (anesthesia, paresthesia, dysesthesia), and identify possible contributing factors such as osteotomy design and additional genioplasty procedure.

4.1. Skeletal and Dental Stability

The evaluation of dental and skeletal stability has a major contribution and allows the surgeon to predict the final occlusion. In this study, skeletal stability was measured by assessing the SNB angle and the distance between the Co and B points. The mean distance between the Co and B points at T2 was 104.89 mm compared to 106.15 mm at T1; the changes from T1 to T2 were not statistically significant ($p = 0.07$), representing skeletal stability with a mean relapse of 1.6 mm backward movement that is considered stable [16]. The results of our present study are consistent with other findings in the common literature that describe the backward displacement of the mandible after 1-year follow-up [16–19]. A possible cause of backward displacement could be the gravity of the mandible, the soft tissues attached to it and muscle pull, as described by Steven et al., who reviewed skeletal changes in 41 patients after IVRO and found that the mean movement of the mandible was 0.1 mm backward [17]. The backward displacement of the mandible was also reported by Proffit et al. [16], with a mean backward displacement of about 0.7 mm after 1-year follow-up corresponding with findings by Jung et al. and Ayoub et al. that showed posterior movement after IVRO [18,19].

At T2, the mean SNB angle was 79.99 (SD = 4.39), while at T1, the mean SNB was 81.71, with a significant difference ($p < 0.01$). This finding also indicates the backward movement of the B point and possible clockwise rotation of the mandible that could relate to the position of the condyle after the release of IMF fixation as part of the “sag” phenomenon that was described by Yoshioka et al. [4].

Dental stability was evaluated for a period of 8 months after the surgery, from T1 to T2. The changes regarding the overbite ($p = 0.19$) and overjet ($p = 0.46$) were measured in during this period and were not found to be statistically significant; furthermore, the mean relapse was less than 2 mm (OB = 0.17 mm, OJ = −0.06 mm).

4.2. Neurologic Disturbance

According to the literature, the main advantage of the IVRO over the SSRO is the lower incidence of IAN injury during surgery. In IVRO, the prevalence of injuring the IAN is considered lower but might still occur while performing the osteotomy or the manipulation of the distal fragment [2,4,12].

Previous studies and meta-analyses report an incidence of 0–36% for immediate IAN injury, while the prevalence of long-term damage is considered low—2.3–14% [7]. There is a wide range regarding injury incidence due to the differences in examination techniques, variation in follow-up periods, surgeon experience, and modified IVRO
technique (osteotomy design), as well as performing additional mandibular surgery such as genioplasty.

In our study, 38.46% of the patients had a sensory disturbance in the short term, and 20.51% of them remained with long-term sensory disturbance. When we classified the type of neurosensory injury, only one patient (2.56%) suffered from nerve anesthesia in the long term. Eighteen out of the thirty-nine patients were treated with genioplasty in addition to IVRO, and 27.7% of them reported long-term sensory disturbance. When genioplasty is performed, there are two more steps when an injury to IAN might occur: during exploration and tissue retraction and while performing the osteotomy [11].

The high rate of genioplasty undertaken in our study most likely affected the incidence of IAN injury, based on the fact that in the group of patients that had only IVRO surgery, only 14.2% reported long-term sensory disturbance in comparison to 27.7% of the patients that had an additional genioplasty.

Another interesting finding was the difference in the rate of sensory disturbance between the two osteotomy designs (vertical and oblique); even though no statistically significant connection was found when a vertical osteotomy was made, IAN neurological damage was 174% higher compared to an oblique osteotomy. The effect of the osteotomy design on the different incidence rates of IAN disturbance could be caused by the fact that vertical osteotomy requires more bone cutting in close proximity to the mandibular canal and an additional stripping of the medial pterygoid muscle compared to oblique osteotomy. We believe that in further research that includes a larger patient sample, there will be a correlation between the osteotomy design and IAN neurologic disturbance; furthermore, the osteotomy design could have an effect on other complications, such as TMD, as previously mentioned by Kawase-Koga-Y et al. [3], who demonstrated that among 50 oblique osteotomy lines, no complications such condylar luxation were found as opposed to 98 vertical osteotomy line.

The rates of long-term IAN disturbances in our study are similar to previous reports [7,12], which indicates that low neurosensory alterations can be expected following IVRO procedures, and this finding should be considered when selecting a surgical procedure to correct mandibular prognathism.

4.3. TMJ Dysfunction

In the existing literature, there is controversy on the effect of orthognathic surgery on the TMJ. Several studies [20–22] reported that performing orthognathic surgery, especially IVRO, improves TMJ disorders and pain due to the fact that the condyle tends to move in an anterior and inferior direction, reducing pressure on the articular disc. Additionally, the absence of rigid fixation in IVRO allows the condyle to return to its physiologic equilibrium position. Another explanation could be related to the hypothesis that there is a difference in the morphological TMJ in skeletal class III that affects TMJ function, supporting the fact that after orthognathic surgery, the condyle is restored to its natural position and that may contribute to the improvement of TMJ disorders [23]. In this study, TMJ disorders and dysfunctions were examined before and after the surgery. Twenty-three percent of the patients reported at least one symptom regarding TMJ at T0, as opposed to only 15.3% at T2; thus, improvement was observed, but it was not statistically significant ($p = 0.089$). A lack of a statistical difference could be caused by the small number of patients examined.

4.4. IMF Compliance

One of the main disadvantages of IVRO is the need for IMF for a period of 6 weeks following the surgery—a condition that might be difficult and inconvenient for some patients. In this study, there was full compliance (100%) of the patients during the period (6 weeks after the surgery). IMF allowed for technique simplicity and decreased operative time regarding the need for the increased exploration of adjacent structures, including IAN, for applying rigid fixation in BSSO.
5. Conclusions

IVRO is still a relevant and sound surgical technique for the treatment of mandibular prognathism that provides stable results with a minimal complication rate when compared to SSRO. Further studies are required in order to evaluate the stability of the technique and TMJ function based on the osteotomy design.

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Data Availability Statement: Data are available by request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References


