

The Direction of Double-Jaw Surgery Relapse for Correction of Skeletal Class III Deformity: Bilateral Sagittal Split Versus Intraoral Vertical Ramus Setback Osteotomies

Ra'ed Mohammed Ayoub Al-Delayme^{1,2,3} · Ali Arkan Redha Alsagban^{2,3} · Fires Taha Ahmed⁴ · Ahmad Farag⁵ · Tumouh Al-Allaq⁶ · Parveen Virdee¹ · Zaid Alnajjar⁶ · Sufian Alaa Ibraheem Alsamarai⁷ · Salih Elnashef¹ · Layla Arab⁸ · Alaa Yassin⁹ · Moutaz AL-khen¹⁰

Received: 20 November 2016 / Accepted: 30 May 2018 / Published online: 4 June 2018
© The Association of Oral and Maxillofacial Surgeons of India 2018

Abstract

Objectives This prospective comparative clinical trial study aims to investigate the postoperative stability of the double-jaw surgical treatment of skeletal Class III deformity and to compare two different mandibular surgical approaches. The study goal is to locate the relapsing direction of both the maxilla and the distal segment after either bilateral sagittal split ramus osteotomy (BSSO), or intraoral vertical ramus osteotomy (IVRO).

Methods Twenty-two (22) patients with skeletal Class III were included in this study. The patients were treated with double-jaw surgery by LeFort I osteotomy combined with either BSSO or IVRO. Lateral cephalograms taken before

(T0), immediately after (T1), and 1 year after the surgery (T2) were studied and analyzed.

Result The mean mandibular setback and maxillary advancement in the BSSO group were 6.22 mm at B Point and 2.93 mm at A point with relapse percentages of 24.9 and 26.6%, respectively, while the mean mandibular setback and maxillary advancement in the IVRO group were 2.55 mm at B point and 5.89 mm at A point with relapse percentages of 22.1 and 23.5%, respectively. The magnitude of the setback significantly accounted for the relapse.

Conclusion One-year follow-up revealed that the maxilla would be displaced posteriorly and inferiorly in both groups. Regarding the direction of the mandibular relapse, the mandible in BSSO surgical group was displaced forward and upward, while in IVRO surgical group, the directions were completely different in which the mandible is displaced backward and downward.

✉ Ra'ed Mohammed Ayoub Al-Delayme
Raedmaxfax@gmail.com; Raedmaxfax@yahoo.com

¹ Eastman Institute for Oral Health, University of Rochester, School of Medicine and Dentistry, New York, USA

² Faculty of Dentistry, Dijlah University College, Baghdad, Iraq

³ Oral and Maxillofacial Department, Alyarmouk Teaching Hospital, Baghdad, Iraq

⁴ Oral and Maxillofacial Department, Al-Shaheed Ghazi Al-Hariri Specialized Surgeries, Baghdad, Iraq

⁵ University of Vermont Health Network – AHMC, Malone, NY, USA

⁶ Chesapeake Health Care, Princess Anne, Maryland, USA

⁷ Romo dental, Chicago, Illinois, USA

⁸ Oral and Maxillofacial Surgery Department, University of Washington, Seattle, USA

⁹ Graduate Periodontics Department, University of Washington, Seattle, USA

¹⁰ Oral and Maxillofacial Department, Damascus Hospital, Damascus, Syria

Keywords Class III · Orthognathic surgery · Relapse · Bilateral sagittal split osteotomy (BSSO) · Intraoral vertical osteotomy (IVRO)

Introduction

The Class III malocclusion can be classified into mandibular prognathism, maxillary retrognathism, or a combination of both depending on the variation of the anteroposterior relationships [3]. Treatment of severe Class III malocclusion frequently requires a combination of orthodontics and orthognathic surgical procedures [15].

Mandibular setback osteotomy has been used routinely as an orthognathic surgical procedure for mandibular prognathism [8].

The aim of such methods is to improve facial esthetics and to harmonize the facial profile. These techniques enable the clinicians to predict the soft tissues changes resulting from alterations of the hard tissues [7].

Different methods are developed to perform mandibular setback surgeries [16]. Two surgical techniques are commonly used: bilateral sagittal split ramus osteotomy (BSSO) and intraoral vertical ramus osteotomy (IVRO), or a combination of both (IVRO + BSSO) [13, 18].

The bilateral sagittal split osteotomy of the mandible (BSSO) is the surgical technique that widely uses modality for mandibular prognathism that was introduced by Schuchard and modified by Dal Pont, Trauner, and Obwegeser [4].

While IVRO has been reported to be a suitable method in cases of severe mandibular prognathism to achieve reliable mandibular results [13], IVRO procedure offers numerous advantages over BSSO for the treatment of the prognathic patient, including a lower incidence of injury or damage to the inferior alveolar nerve, technical simplicity, reduced surgical time, and the ability to repossess the condyle [12].

Currently, the trend is to combine and to simultaneously perform maxillary and mandibular osteotomies for correction of facial deformities, which has become a routine procedure [9] to improve occlusion, masticatory function, and esthetics by markedly changing the position of the mandible and maxilla [10].

Following operations for the mandibular setback, a potential skeletal relapse is of concern that should be increasingly taken into consideration [9, 19]. Considerable data are published regarding stability and its related factors after BSSO setback in different methods [8, 9, 16, 19]. Comparatively, only one article has addressed postoperative stability after the setback in IVRO versus BSSO in single-jaw surgeries [25].

According to our knowledge, the last published article by the same author [2] was the first article that mentioned the relapse in these two procedures with limited sample during double-jaw surgeries. In fact, there has been no study that describes relapse and its directions in the vertical and horizontal planes after IVRO and BSSO in double-jaw surgery for correction of skeletal Class III deformity. This study is the first prospective comparative clinical trial to investigate and compare the postoperative stability and locate the direction of maxilla and distal segment relapses after IVRO and BSSO in double-jaw surgery for correction of skeletal Class III deformity.

Materials and Methods

Twenty-two patients (9 females and 13 males) with a mean age of 22.4 ± 4.3 years, ranging from 18.3 to 26.8 years, who received the double surgical correction of dental and skeletal Class III were studied over a period of 2 years in multi-oral and maxillofacial surgery Centers.

Inclusive criteria were patients above 18 years old and mandibular setback through and mandibular BSSO or IVRO with a combination of LeFort I maxillary osteotomy for both groups.

Exclusion criteria were patients with chin deviation, body dysmorphic disorder, known history of facial trauma or congenital deformities, and severe temporomandibular joint (TMJ) symptoms.

All patients were studied by comprehensive clinical oral and maxillofacial examination and 2-dimensional cephalometric radiographic analyses, within 1 week before the surgery (T0), immediately after the surgery, which was not delayed for longer than 7 days (T1), and 1 year after surgery (T2). All cephalometric radiographs and the clinical photographs were standardized for all cases to assess suitability for surgery and to select the most appropriate course of action. The changes during the operation were measured by cephalometric indices.

The 22 consecutive patients were separated into 11 IVRO surgery and 11 BSSO setback surgery cohorts according to the thickness of the ramus during the surgery. Patients who had a suitable ramus width for splitting without any intraoperative complication underwent BSSO; otherwise, patients underwent IVRO.

The protocol of this study was approved by the local hospital Committee for Research Ethics Concerning Human Subjects according to Helsinki guidelines. Each of the participating patients signed an informed consent provided with an information sheet and contact details of the investigators. The minimum postoperative follow-up period was 12 months, and postoperative radiographs were taken when appropriate.

Presurgical orthodontic preparation included dental decompensation; postsurgical treatment included orthodontic finishing, dental alignment, consolidation and coordination of the maxillary and mandibular arches.

Patients' demographics, the length of the presurgical orthodontic treatment period, and the degree of overjet and overbite are presented in Table 1.

Surgical Procedures

After presurgical orthodontic treatment, a lateral cephalograph was obtained for planning the surgical movement of

Table 1 Patient gender, age, length of presurgical orthodontics, and degree of overjet and overbite

	BSSO	IVRO	Both procedures	<i>P</i> values
Male gender	7	6	13	0.318
Female gender	4	5	9	
Age at surgery (years)	21.5 ± 3.8	23.3 ± 5.1	22.4 ± 4.3	0.366
Degree of over jet (mm)	− 4.7 ± 5.9	− 3.9 ± 2.68	− 4.3 ± 4.2	0.894
Degree of open bite (mm)	0.6 ± 1.3	0.85 ± 1.1	0.71 ± 1.19	0.845
Presurgical orthodontics (month)	8.7 ± 9.2	11.4 ± 6.4	10.1 ± 7.7	0.919

the mandible. Surgical models and fabrication of surgical stent were performed on semi-adjustable articulators.

All surgical procedures were performed under nasal intubation and general anesthesia to surgically reposition the maxilla in standard LeFort I setback osteotomy; the BSSO group underwent BSSO in the standard Dal Pont fashion [4], and IVRO was performed according to the method of Hall et al. [13].

In both groups, the maxilla was moved forwards and upwards at A point, and no downward movement was performed, while the mandible underwent horizontal setback and vertical downward movement at B point and pogonion as shown in Table 2.

Surgeries were performed by qualified oral and maxillofacial surgeons. After finishing the osteotomies and splitting of the maxilla and distal and proximal mandibular segments, the intermaxillary position was corrected and guided by the acrylic surgical stent.

The bony segments were fixed in the new position with the use of a monocortical plating system and intraoral approach (Leibinger; 2.0 mm diameter). One monocortical plate per side was used on the BSSO and four monocortical plates for the maxilla, while IVRO was performed without any fixation system.

Postoperative recoveries were uneventful, and all patients were discharged from the hospital within a few days of surgery. The acrylic stent stabilized by orthodontic

wires was preserved in the maxilla for 1 month to guide the jaw movement into the new position. Maxillomandibular fixation (MMF) was released at (6–8 weeks) post-surgery in both groups. Elastic tractions were used for at least 3 months after surgery to functionally control the post-surgical mandibular positions.

Cephalometric Analysis

All cephalometric radiographs were traced and analyzed by an experienced clinician. The linear measures on lateral cephalograms used in this study are illustrated in Fig. 1. *X* and *Y* measurements were taken using a line parallel to the Frankfort horizontal plane at the nasion for the *X* coordinate. A perpendicular line was then drawn intersecting the first line at the nasion. The *X* and *Y* axes were transcribed into each successive radiograph by superimposition on the best fit of cranial base landmarks. Cephalometric radiographs had to be obtained for each patient 1 week preoperatively (T0), 1 month postoperatively (T1), and 1 year postoperatively (T2).

Statistical Analysis

The skeletal changes were measured by cephalometric indexes, and all measurements were repeated twice and over two consecutive days. The errors of the two sets of

Table 2 Mean dental and skeletal changes in cephalometric parameters for the BSSO procedure

	T0–T1		T0–T2	
	<i>X</i>	<i>Y</i>	<i>X</i>	<i>Y</i>
A (mm)	2.93 ± 1.1 ^b	2.1 ± 1.4 ^c	− 1.87 ± 1.3 ^a	2.25 ± 1.55 ^a
B (mm)	− 4.22 ± 1.95 ^b	− 1.43 ± 0.45 ^c	− 3.7 ± 1.24 ^a	− 2.3 ± 0.57 ^b
Pg (mm)	− 4.78 ± 1.88 ^b	− 1.16 ± 0.25 ^c	− 3.04 ± 1.59 ^a	− 1.83 ± 0.19 ^a
Over jet (mm)	5.6 ± 3.27 ^a		5.49 ± 3.11 ^b	
Overbite (mm)	− 0.64 ± 1.5		1.31 ± 1.26 ^c	

Horizontal changes: positive value indicates anterior movement and negative value indicates posterior movement; vertical changes: positive value indicates inferior movement and negative value indicates superior movement; dimensional changes: positive value indicates an increase and negative value indicates a decrease. T0, 1 week before surgery; T1, 1 week after surgery; T2, 1 year after surgery; *X*, horizontal changes; *Y*, vertical changes; A point; B point; Pg, pogonion

^a*P* < 0.001; ^b*P* < 0.01; ^c*P* < 0.05

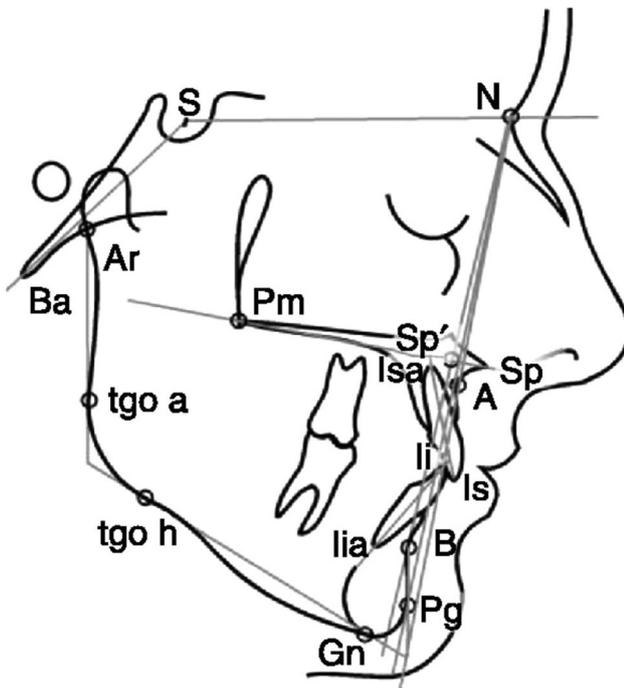


Fig. 1 Reference points and cephalometric landmarks used in the study

tracings and measurements were estimated by paired-sample *t* test and the Dahlberg formula. The magnitude of measurement of error was < 1 mm for all of the horizontal and vertical measurements.

Student's *t* test for paired data was used to test statistical significance of changes in variables among each cohort and at different stages.

Within each group, Pearson correlation coefficients were calculated to analyze whether skeletal relapse was related to surgical repositioning. The differences between the two procedures at each measurement were assessed by unpaired *t* tests.

Results

Mean clinical and paraclinical changes in the two surgical groups before (T0), immediately after (T1), and 1 year after the surgery (T2) were analyzed in two time intervals (T0–T1) and (T0–T2), presented in Tables 3 and 4.

The statistical analysis showed that both BSSO and IVRO groups had similar morphologic changes (Table 5). There were similar amounts of postoperative horizontal and vertical mandibular changes.

BSSO Group Procedures (Table 2)

Skeletal changes: Based on clinical findings, the mean intraoperative maxillary advancement was 2.93 ± 1.1 mm, and mandibular setback was 6.22 ± 1.95 mm.

The mean setback of the mandible after surgery (T0–T1) was 4.22 ± 1.95 mm at point B and 4.78 ± 1.88 mm at pogonion. One year later, the mandible displaced forward 1.05 ± 1.21 mm; $P < 0.001$ and upward -0.87 ± 0.52 mm; $P < 0.001$ at B point representing 24.9% of the mandibular setback, while the maxilla displaced posteriorly 0.68 ± 0.55 mm; $P < 0.001$ and inferiorly 0.15 ± 1.47 mm; $P < 0.001$ representing 26.6% of maxillary advancement.

Incisal relationships: At the end of the follow-up period, mean overjet was (5.6 ± 3.27) mm). None of the patients had an overjet of < 1.0 mm. Mean overbite at the end of the follow-up period was 0.64 ± 1.5 mm.

Correlation: The correlation between surgical setback at B and Pg points and relapse at B and Pg points was weak but significant $P < 0.05$ for mandibular stability, while in maxilla a significant correlation was found between the surgical advancement at A and relapse $P < 0.001$ for maxillary stability.

IVRO Group Procedures (Table 3)

Skeletal changes: Based on clinical findings, the mean intraoperative maxillary advancement was 2.55 ± 0.85 mm, and mandibular setback was 5.89 ± 1.75 mm. The mean setback of the right mandible after surgery (T0–T1) was 3.89 ± 1.75 mm at point B, 4.23 ± 1.47 mm at pogonion. One year later, the mandible displaced backward -0.56 ± 1.16 mm; $P < 0.001$ and downward 1.0 ± 0.44 mm; $P < 0.001$ at B point representing 22.1% of the mandibular setback. The maxilla displaced posteriorly 0.6 ± 0.36 mm; $P < 0.001$ and inferiorly 0.13 ± 1.29 mm; $P < 0.001$ representing 23.5% of maxillary advancement.

Incisal relationships: At the end of the follow-up period, mean overjet was 5.4 ± 2.95 mm. None of the patients had an overjet of < 1.0 mm. Mean overbite at the end of the follow-up period was 0.45 ± 1.37 mm.

Correlation: The correlation between surgical setback at B and Pg points and relapse at B and Pg points was highly significant $P < 0.001$ for mandibular stability; also, in maxilla a significant correlation was found between surgical advancement at A and relapse $P < 0.001$ for maxillary stability.

Table 3 Mean dental and skeletal changes in cephalometric parameters for the IVRO procedure

	T0–T1		T0–T1	
	X	Y	X	Y
A (mm)	2.55 ± 0.85 ^a	1.75 ± 1.6 ^a	1.95 ± 0.76 ^a	1.88 ± 1.4 ^a
B (mm)	– 3.89 ± 1.75 ^a	– 1.37 ± 0.37 ^a	– 4.45 ± 1.36 ^a	0.37 ± 0.28 ^a
Pg (mm)	– 4.23 ± 1.47 ^a	– 1.19 ± 0.22 ^a	– 5.69 ± 1.55 ^a	0.65 ± .20 ^a
Overjet (mm)	5.4 ± 2.95 ^a		5.5 ± 2.78 ^a	
Overbite (mm)	– 0.45 ± 1.37 ^c		0.3 ± 1.33 ^b	

Notes and abbreviations as in Table 3

^a*P* < 0.001; ^b*P* < 0.01; ^c*P* < 0.05**Table 4** Postoperative cephalometric measurements of both surgical groups

	BSSO group	IVRO group	<i>P</i> values
A (horizontal)	2.93 ± 1.1	2.55 ± 0.85	0.96
A (vertical)	2.1 ± 1.4	1.75 ± 1.6	0.42
B (horizontal)	– 4.22 ± 1.95	– 3.89 ± 1.75	0.68
B (vertical)	– 1.43 ± 0.45	– 1.37 ± 0.37	0.80
Pg (horizontal)	– 4.78 ± 1.88	– 4.23 ± 1.47	0.30
Pg (vertical)	– 1.16 ± 0.25	– 1.19 ± 0.22	0.76
Over jet	5.6 ± 3.27	5.4 ± 2.95	0.69
Overbite	– 0.64 ± 1.5	– 0.45 ± 1.37	0.34

BSSO Versus IVRO Surgical Groups

Skeletal Changes

In both surgical groups, there were significant changes in vertical and horizontal positions at A point of the maxilla (Table 5).

Regarding mandibular horizontal stability at B, the BSSO surgical procedure group had a significant greater

relapse than the IVRO surgical procedure group after 1 year 1.05 versus 0.56 mm; *P* < 0.01. The same relationship was identified when assessing skeletal changes at Pg, while the vertical stability relapse somewhat was less in BSSO with weak but significant correlation 0.87 versus 1.0 mm; *P* < 0.05. No differences were noted when examining the incisal relationship (Table 4).

The Direction of Mandibular Relapse

After 1 year in both groups the maxilla displaced posteriorly and inferiorly. In BSSO surgical group, the mandible displaced forward and upward, while in IVRO the directions were completely different in which the mandible displaced backward and downward (Table 5).

The statistical data revealed that patient age and sex had no significant effects on relapse in either group. The presurgical orthodontic treatment had a strong correlation with relapse reduction *P* < 0.001, and a weak but significant correlation *P* < 0.05 was found between postsurgical orthodontics and relapse (Table 6).

Table 5 Correlation between mean of surgical movements, mean, percentage and direction of relapse in both procedures

	Mean of surgical movements		Mean of relapse		Percentage of relapse		Direction of relapse		<i>P</i> values
	BSSO	IVRO	BSSO	IVRO	BSSO	IVRO	BSSO	IVRO	
A (horizontal)	2.93 ± 1.1	2.55 ± 0.85	– 0.68 ± 0.55	– 0.6 ± 0.36	26.6	23.5	–	–	0.34
A (vertical)	– 2.93 ± 1.1	– 1.75 ± 1.6	0.15 ± 1.47	0.13 ± 1.29	7.1	7.4	+	+	0.30
B (horizontal)	– 6.22 ± 1.95	– 5.89 ± 1.75	1.05 ± 1.21	– 0.56 ± 1.16	24.9	22.1	+	–	0.001 ^a
B (vertical)	– 1.43 ± 0.45	– 1.37 ± 0.37	– 0.87 ± 0.52	1.0 ± .44	61.3	57.2	–	+	0.04 ^b
Pg (horizontal)	– 6.78 ± 1.88	– 6.23 ± 1.47	1.74 ± 1.48	– 1.46 ± 1.57	36.5	34.6	+	–	0.001 ^a
Pg (vertical)	– 1.16 ± 0.25	– 1.19 ± 0.22	– 0.67 ± 0.20	0.54 ± .31	58.3	54.7	–	+	0.02 ^b
Over jet	5.6 ± 3.27	5.4 ± 2.95	– 0.11 ± .04	0.05 ± 0.04	2.1	1.8	+	–	0.82
Overbite	0.64 ± 1.5	– 0.45 ± 1.37	1.77 ± 0.69	0.15 ± .58	36.3	33.5	–	+	0.84

^a*P* < 0.001; ^b*P* < 0.05

Table 6 Correlation between age, gender, presurgical and postsurgical orthodontics in both procedures

	BSSO	IVRO	<i>P</i> value
Female	3	5	0.50
Male	5	4	
Age at surgery (years)	23.3 ± 5.1	21.5 ± 3.8	0.70
Presurgical orthodontics (months)	11.4 ± 6.4	8.7 ± 9.2	0.001 ^a
Postsurgical orthodontics (months)	5.9 ± 1.7	5.2 ± 2.1	0.048 ^b

^a*P* < 0.001; ^b*P* < 0.05

Discussion

Various techniques and modifications have been introduced in the treatment of mandibular prognathism [2–4, 7–10, 12, 13, 15, 16, 18, 19, 25]. The number of patients undergoing combined maxillary and mandibular (known as double-jaw surgery) for correction of Class III skeletal relationship is increased [9, 19]. Post-treatment relapse is an unpredictable risk of orthognathic surgery [6]. Although the broad experience with this procedure, relapse or movement of an anatomic point toward its presurgical position is not uncommon [1, 2, 9, 19], there is controversy regarding skeletal stability after bi-maxillary operation [22, 25].

Consistently, many studies [1, 2, 9, 10, 19] are published concerning the stability of BSSO for the mandibular setback in bi-maxillary surgery in different techniques and modalities, but it is rather surprising that there are no reports concerning stability of IVRO in double-jaw surgery. The only three conducted studies in the literature discussed the IVRO stability in single-jaw surgery as isolated procedures [16, 21, 25] or as a comparison with BSSO in double-jaw surgery [1].

The purpose of this prospective comparative clinical trial study is to investigate and compare the postoperative stability and to locate the direction of maxillary and distal segment relapses after IVRO and BSSO in double-jaw surgery (combined with maxillary LeFort I surgery) for correction of skeletal Class III deformity. As usual, results from any study should be discussed in light of other similar findings. Unfortunately, no previous prospective study has compared the two techniques in double-jaw surgery for the treatments of Class III dentofacial deformities, and therefore, until replicated, these results stand alone and can only be partially discussed.

The present findings support correlations between the magnitude of surgical movement and the subsequent skeletal relapse for both BSSO and IVRO surgical groups, which is in contrast to our previous findings [2] and another article regarding BSSO mandibular setback in double-jaw surgery [1].

Kwon et al. [14] stated that LeFort I osteotomy is considered a safe and predictable method for correcting

various dentofacial deformities. This observation agrees with a previous study regarding the stability of double-jaw surgery versus single-jaw surgery for treatment of skeletal Class III [1], which confirms that no significant correlation is found between surgical advancement and relapse when it comes to maxillary stability. In the present study, there are highly significant changes in vertical and horizontal positions at A point of the maxilla in both surgical groups.

From the point of view that mandibular stability influences maxillary surgical changes, this study confirms that the relapsing of the maxilla is influenced by mandibular stability. These results are contrary to the ones found by Kwon et al. [14], who concluded that maxillary advancement and vertical changes of 2 mm did not influence the postoperative stability of the mandible, and the relapse of the mandible seemed to be influenced mainly by the amount and direction of the surgical alteration of mandibular position.

In this study, the incidence of inferior alveolar nerve injury was minimized by using monocortical screws in BSSO and using no fixation system in IVRO procedures. The plating system offers advantages such as reduction in the incidence of inferior alveolar nerve injury, minimal access required when applied (i.e., transcutaneous approach), and prevention of rotation of the mandibular condyles, which can occur with bicortical screws [11].

In our literature review [1, 12, 16, 21, 25], we found that the IVRO procedure has been used widely in patients undergoing orthognathic surgery with jaw deformities, especially mandibular prognathism. This procedure is relatively easy, and only one case showed sensory disturbances due to surgical damage of the inferior alveolar nerve. The incidence of inferior alveolar nerve injury associated with IVRO is less than 1% [5]. Conversely, neurologic deficit associated with BSSO has been reported to be as high as 85% [17], where a complete transection of nerve has a reported incidence of 2–3.5% [23]. Another benefit of IVRO is the ability to repossess the condyle [12]. Although the incidence of temporomandibular joint internal derangement is low after BSSO, it is even lower after IVRO.

Yoshioka et al. [25] treated fifteen patients with skeletal mandibular prognathism in 2008 and stated that the single-

jaw IVRO procedure offers some advantages over sagittal split ramus osteotomy for treatment of the prognathic patient. They concluded that at 1 year after surgery, there was no significant difference between the two groups in the stability of the B point and the pogonion, in addition to the stability after IVRO, which is equal to that after sagittal split ramus osteotomy with semirigid internal fixation. This observation has been concluded in some other recent studies [1], which researched double-jaw surgeries too.

In a very interesting finding, BSSO resulted in a significantly greater horizontal relapse than IVRO after 1 year 1.05 versus 0.56 mm; $P < 0.01$, while there was a weak but significant correlation in vertical stability in BSSO 0.87 versus 1.0 mm; $P < 0.05$.

Another interesting clinical finding in this study is the correlation between the direction of skeletal relapse and types of surgical operation used to setback the mandible in double-jaw surgeries. We observed that after 1 year in both groups the maxilla was displaced posteriorly and inferiorly. In BSSO surgical group the mandible displaced forward and upward, while in IVRO, the directions are completely different in which the mandible displaced backward and downward.

Yoshioka et al. [25] presented that in all IVRO cases, distal segments of the mandible relapsed posteriorly and inferiorly immediately after the releasing of MMF. We also found this in the IVRO group, in which the distal segments continued to relapse in posterior and inferior directions affected by the postoperative changes of maxillae (which relapse in posterior and inferior directions). In our IVRO group, the mandible was expected to follow the maxilla due to the lack of fixation between the two mandibular segments as we described in “Materials and Methods” section.

It is evident that the BSSO distal segments moved in a forward and upward direction, which was not influenced by the movement of the maxilla. This can be explained because of the rigid fixation performed using monocortical plates. This relapsing direction of the BSSO group is confirmed by all other related published values [1, 2, 9, 10, 19].

Many studies have assessed several factors affecting and implicating the relapse. Wolford et al. [24] suggested that some of these factors could be avoidable (unstable presurgical orthodontic treatment, the condyle being forced posteriorly in the fossa, positioning the proximal segment by pushing posteriorly on its anterior edge, use of occlusal splints that may create an upward and forward rotation of the mandible., etc.). Kwon et al. [14] commented that the magnitude of the setback was the main factor of relapse, whereas the fixation technique and the use of IMF/MMF were reported to be risk factors by Choi [8]. The use of an

appliance for repositioning the proximal segment to prevent the relapse was recommended by Renzi et al. [20].

Conclusion

This study has revealed that after 1 year the maxilla was displaced posteriorly and inferiorly in both groups. Regarding the mandibular relapse direction, the mandible in the BSSO surgical group displaced forward and upward, while in IVRO surgical group the directions are completely different in which the mandible displaced backward and downward.

Authors’ Contribution RA, AA, FA, and MA designed and performed the study, carried out the literature research and manuscript preparation. RA, AA, FA, MA, AF, TA, PV, SAL, ZAl, SE, AY, and LA were responsible for critical revision of scientific content and manuscript review. All authors approved the final version of the manuscript.

Compliance with Ethical Standards

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

References

1. Al-Delayme R, Al-Khen M, Hamdoon Z, Jerjes W (2013) Skeletal and dental relapses after skeletal class III deformity correction surgery: single-jaw versus double-jaw procedures. *Oral Surg Oral Med Oral Pathol Oral Radiol* 115:466–472
2. Al-Delayme RM, Al-Khen M (2014) Skeletal relapse after mandibular setback in bi max surgery: intraoral vertical ramus versus bilateral sagittal split osteotomies. *J Maxillofac Oral Surg* 13:471–477
3. Al-Gunaid T, Yamada K, Takagi R, Saito C, Saito I (2008) Postoperative stability of bimaxillary surgery in Class III patients with mandibular protrusion and mandibular deviation: a frontal cephalometric study. *Int J Oral Maxillofac Surg* 37:992–998
4. Bailey LT, Proffit WR, White RP Jr (1995) Trends in surgical treatment of Class III skeletal relationships. *Int J Adult Orthodon Orthognath Surg* 10:108–118
5. Bell WH, Yamaguchi Y (1991) Condyle position and mobility before and after intraoral vertical ramus osteotomies and neuromuscular rehabilitation. *Int J Adult Orthodon Orthognath Surg* 6:97–104
6. Borstlap WA, Stoelinga PJ, Hoppenreijts TJ, van’t Hof MA (2004) Stabilisation of sagittal split advancement osteotomies with miniplates: a prospective, multicentre study with two-year follow-up. Part III—condylar remodelling and resorption. *Int J Oral Maxillofac Surg* 33:649–655
7. Chen F, Terada K, Hua Y, Saito I (2007) Effects of bimaxillary surgery and mandibular setback surgery on pharyngeal airway measurements in patients with Class III skeletal deformities. *Am J Orthod Dentofac Orthop* 131:372–377
8. Choi HS, Rebellato J, Yoon HJ, Lund BA (2005) Effect of mandibular setback via bilateral sagittal split ramus osteotomy on transverse displacement of the proximal segment. *J Oral Maxillofac Surg* 63:908–916

9. Costa F, Robiony M, Zorzan E, Zerman N, Politi M (2006) Stability of skeletal Class III malocclusion after combined maxillary and mandibular procedures: titanium versus resorbable plates and screws for maxillary fixation. *J Oral Maxillofac Surg* 64:642–651
10. Degerliyurt K, Ueki K, Hashiba Y, Marukawa K, Simsek B, Okabe K, Nakagawa K, Yamamoto E (2009) The effect of mandibular setback or two-jaws surgery on pharyngeal airway among different genders. *Int J Oral Maxillofac Surg* 38:647–652
11. Fujioka M, Fujii T, Hirano A (2000) Comparative study of mandibular stability after sagittal split osteotomies: biocortical versus monocortical osteosynthesis. *Cleft Palate Craniofac J* 37:551–555
12. Ghali GE, Sikes JW Jr (2000) Intraoral vertical ramus osteotomy as the preferred treatment for mandibular prognathism. *J Oral Maxillofac Surg* 58:313–315
13. Hall D (1980) Intraoral vertical ramus osteotomy. In: Bell WH (ed) *Surgical correction of dentofacial deformities*, vol 2. Saunders, Philadelphia, pp 890–895
14. Kwon TG, Mori Y, Minami K, Lee SH, Sakuda M (2000) Stability of simultaneous maxillary and mandibular osteotomy for treatment of class III malocclusion: an analysis of three-dimensional cephalograms. *J Craniomaxillofac Surg* 28:272–277
15. Marsan G, Oztas E, Kuvat SV, Cura N, Emekli U (2009) Changes in soft tissue profile after mandibular setback surgery in Class III subjects. *Int J Oral Maxillofac Surg* 38:236–240
16. Mohajerani H, Mehdizadeh M, Khalighi A (2009) Skeletal relapse after correction of mandibular prognathism by bilateral sagittal split ramus osteotomy. *J Dent* 6(3):139–144
17. Nishioka GJ, Zysset MK, Van Sickels JE (1987) Neurosensory disturbance with rigid fixation of the bilateral sagittal split osteotomy. *J Oral Maxillofac Surg* 45:20–26
18. Nwoku AL, Palomero-Rodriguez R, Horch HH (1974) The problems of correction of asymmetric mandibular prognathism. *Int J Oral Surg* 3:229–233
19. Politi M, Costa F, Cian R, Polini F, Robiony M (2004) Stability of skeletal class III malocclusion after combined maxillary and mandibular procedures: rigid internal fixation versus wire osteosynthesis of the mandible. *J Oral Maxillofac Surg* 62:169–181
20. Renzi G, Becelli R, Di Paolo C, Iannetti G (2003) Indications to the use of condylar repositioning devices in the surgical treatment of dental-skeletal class III. *J Oral Maxillofac Surg* 61:304–309
21. Talesh KT, Motamedi MH, Sazavar M, Yazdani J (2010) Assessment of relapse following intraoral vertical ramus osteotomy mandibular setback and short-term immobilization. *Eplasty pii:e54*
22. Watzke IM, Heinrich A (2002) The impact of bilateral sagittal split osteotomy on mandibular width and morphology. *J Oral Maxillofac Surg* 60:502–504
23. Westermarck A, Bystedt H, von Konow L (1998) Inferior alveolar nerve function after mandibular osteotomies. *Br J Oral Maxillofac Surg* 36:425–428
24. Wolford LM (2000) The sagittal split ramus osteotomy as the preferred treatment for mandibular prognathism. *J Oral Maxillofac Surg* 58:310–312
25. Yoshioka I, Khanal A, Tominaga K, Horie A, Furuta N, Fukuda J (2008) Vertical ramus versus sagittal split osteotomies: comparison of stability after mandibular setback. *J Oral Maxillofac Surg* 66:1138–1144