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Skeletal stability after mandibular advancement in bilateral sagittal split osteotomies during adolescence

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den Besten CA
Mensink G
van Merkesteyn JPR

Abstract

Bilateral sagittal split osteotomy (BSSO) is the most frequently performed surgery for correcting mandibular retrognathia. Few studies have reported the use of BSSO at a young age, as growth may cause relapse. The aim of the present study was to determine the amount of relapse after performing BSSO in patients aged less than 18 years. Patients who had a mandibular advancement by BSSO surgery between January 2003 and June 2008 were evaluated. Eighteen patients were treated before the age of 18 years and compared with patients treated at 20 to 24 years of age. Cephalometric radiographs were used to determine the amount of relapse. For patients aged less than 18 years, the mean horizontal relapse after 1 year was 0.5 mm, being 10.9% of the perioperative advancement. For patients aged 20–24 years, the mean relapse was 0.9 mm, being 16.4% of the mean perioperative advancement. There were no significant differences between the age groups ($p > 0.05$). In conclusion, the BSSO procedure is a relatively stable procedure, even during adolescence.

Introduction

Bilateral sagittal split osteotomy (BSSO) was introduced in 1957 by Trauner and Obwegeser [1] and has been modified by several authors over the years. It is the preferred treatment for mandibular advancement, correcting mandibular retrognathia in adult patients.

The stability of the treatment is an important factor in the outcome of this surgery. Skeletal relapse after BSSO is the result of many different factors, including condylar slippage after bad positioning of the condylus during the procedure [2,3], condylar resorption after surgery [4,5], intersegmental relapse at the osteotomy site [6], and further mandibular growth after the BSSO [4].

To avoid relapse because of growth, the age limit for BSSO has been set at 18 years in most clinics. Recent publications about stability of mandibular orthognathic surgery in this journal were also all conducted in an adult study population, with most of population having a mean age of mid-twenty [7-9]. Around the year 1980, a few studies have reported the results of BSSO in younger patients. (Table 1) [10-12]. Because of the high relapse percentages found in these studies (up to 25%), BSSO treatment was more or less limited to patients older than 18 years. However, recent reports on the relative stability of mandibular advancement using distraction osteogenesis have reintroduced the use of BSSO in younger patients. The objective of this study was to determine the amount of relapse in a group of patients who underwent BSSO before the age of 18 years.

Table 1 Skeletal stability of BSSO at a young age.

Author	Number of patients	Mean age patients	Treatment	Mean advancement	Mean relapse at 1 year	Mean relapse/mean advancement
Huang and Ross, 1982	21	14.1 (11.2-16.9)	BSSO	10.9 mm	2.67 mm	24.5%
Wolford et al., 1979	12	13.4 (8-16)	BSSO	5.4 mm	0.24 mm[a]	4.4%
Freihofer, 1977	7	15.7 (13-17)	BSSO	5.5 mm[b]	0.72 mm[b]	13.1%

[a] After 4 months.

[b] Just stated 4-7 mm advancement; two patients with relapse, one 15% and one 80%, and two patients with growth one 1.5% and one 2%.

Material and methods

Surgical records were reviewed retrospectively for the years 2003 until 2008. Patients who underwent BSSO advancement before the age of 18 years or between 20 and 24 years (control group) were included in this study. All patients were treated in the Department of Oral and Maxillofacial Surgery at Leiden University Medical Center. A patient was included when the records were adequate, i.e., containing date and type of surgery, preoperative radiographic examinations, and follow up records with radiographic examinations. Follow-up records had to be available over a period of at least 8 months. A Le Fort I procedure and/or genioplasty conducted in the same surgical setting as well as surgical removal of impacted third molars were not exclusion criteria.

Of the patients who underwent a BSSO advancement between January 2003 and June 2008, 23 were aged less than 18 years. Of these 23 patients, 5 were excluded because follow-up was missing or inadequate. Eighteen patients remained suitable for analysis. From 8 patients preoperative a wrist film was made to determine the skeletal-age. In all 8 wrist films made the radiologist stated that growth plates were not completely closed and/or final height was not yet completely reached. It was concluded that these patients were still actively growing and consequently we could speak of an adolescent group.

From the 18 patients included in 11 patients BSSO was performed without a concomitant procedure; in 1 patient, BSSO was combined with a genioplasty. In 6 patients, BSSO was combined with Le Fort I osteotomy; from which one patient also underwent genioplasty. Fifteen of the patients were female, and 3 were male. The mean age was 16.6 years (SD, 1.0; range, 14.6 to 18.0 years). In 12 patients, the third molars were removed during surgery. The mean follow-up was 13.1 (SD, 1.7) months, with a minimum of 8 months and a maximum of 16 months (Table 2).

The control group (patient age, 20 to 24 years) consisted of 22 patients. Four patients were excluded because of inadequate follow-up. A group of 18 patients remained for analysis. In 7 patients, BSSO was performed without a concomitant procedure. In 11 patients, BSSO was combined with a Le Fort I procedure; in 2 patients, this was combined with genioplasty. Twelve of the patients were female, and 6 were male. The age at the time of osteotomy ranged from 20.1 to 23.8 years, with a mean age of 21.3 $\pm$ 1.2 years. In 7 patients, third molars present in the mandible were removed during surgery. The duration between osteotomy and one-year follow up was an average of 12.3 (SD 1.6) months, with a minimum of 8 and a maximum of 15 months (Table 2).

Table 2 Patient characteristics.

Patient	Age	Sex	Operation	Advancement BY (mm)	Relapse BY (mm)[a]
1	15	F	BSSO	1.8	+0.5
2	17	M	BSSO	5.8	2.2
3	16	M	BSSO	3.5	0.3
4	14	F	BSSO	5.5	+0.2
5	17	F	BSSO	4.8	2.0
6	16	F	BSSO	2.5	0.3
7	17	F	BSSO	3.3	2.5
8	17	F	BSSO	0.7	+1.2
9	16	F	BSSO	3.5	1.2
10	15	F	BSSO	1.5	+1.0
11	16	F	BSSO + genioplasty	1.3	+0.7
12	14	F	BSSO	3.8	1.3
13	17	F	BSSO + Le Fort I	6.7	1.7
14	17	F	BSSO + Le Fort I	11.8	0.2
15	17	F	BSSO + Le Fort I	4.3	2.3
16	16	F	BSSO + Le Fort I	6.7	0.2
17	16	M	BSSO + Le Fort I	7.0	0.3
18	16	F	BSSO + Le Fort I + genioplasty	7.2	+2.2
19	20	F	BSSO	5.8	2.0
20	22	F	BSSO	5.3	1.2
21	20	F	BSSO	1.2	+0.5
22	22	F	BSSO	1.2	+0.2
23	20	F	BSSO	3.5	1.5
24	21	F	BSSO	1.7	0.3
25	21	M	BSSO	4.8	+1.0
26	23	M	BSSO + Le Fort I	4.7	+0.7
27	21	F	BSSO + Le Fort I	5.0	3.2
28	20	F	BSSO + Le Fort I + genioplasty	7.5	+0.3
29	23	F	BSSO + Le Fort I	9.2	3.8
30	20	M	BSSO + Le Fort I	7.8	1.8
31	20	F	BSSO + Le Fort I	7.0	0.2
32	21	M	BSSO + Le Fort I	8.7	0.5
33	20	M	BSSO + Le Fort I	10.8	1.2
34	20	M	BSSO + Le Fort I	5.0	0.2
35	20	F	BSSO + Le Fort I + genioplasty	3.7	0.7
36	20	F	BSSO + Le Fort I	6.5	2.5

[a] Relapse in mm, + is further anterior movement in year after BSSO.

Surgical technique

After general anesthesia and nasotracheal intubation, articaine and epinephrine 1:160.000 (Ultracaine D-S, Aventis, Pharma, Hoevelaken, The Netherlands) were injected submucosally into the operation site to prevent excessive bleeding during the procedure. BSSOs were performed according to the modified method of Hunsuck [13] without the use of chisels. Instead, splitting forceps (Smith Ramus Separator 12 mm, Walter Lorentz Surgical, Jacksonville, FL, USA) and elevators (curved Smith Sagittal Split Separators, Walter Lorentz Surgical, Jacksonville, FL, USA) were used [14,15]. Bone cuts were performed using a Lindemann burr. Splitting was done with the elevator positioned in the vertical bone cut and the forceps in the sagittal bone cut. Once the superior part of the mandible began to split, the elevator was repositioned at the inferior end of the vertical cut, and the splitting was completed. After complete mobilization of the mandible, it was placed into the new intermaxillary position using a wafer. Intermaxillary wire fixation was applied. A stab incision was made in the skin and using a transbuccal retractor, three 2-mm bicortical screws (Martin, GmbH, Tuttlingen, Germany) (length: 9, 11, 13, or 15 mm) were placed bilaterally in the superior part of the mandible. Temporary intermaxillary fixation was removed, and occlusion was checked.

Cephalometric method

To evaluate the stability after BSSO, standard lateral cephalometric radiographs were used. Radiographs were obtained before osteotomy, postoperatively, and 1 year after BSSO in every patient. All radiographs were traced by hand by 1 author (CB). Every radiograph was traced 3 times, and the average data of these 3 tracings were used for further analysis.

To determine the horizontal and vertical relapse, a XY-coordinate system was constructed on each radiograph. The horizontal axis (SNx) was constructed 7 degrees from the sella-nasion line, an approximation of the Frankfort horizontal plane. The vertical axis (SNy) was perpendicular to this line, through the point sella (Figure 1). The perpendicular distance between point B and both axes was determined. The distance between point B and SNx was defined as BX, and the point between B and SNy was BY. Furthermore, SNB and SN-GoGn angles were determined.

Statistical analysis

All statistical analyses were performed using SPSS 17.0 for Windows (SPSS Inc, Chicago, USA). The measurements of the radiographs obtained before osteotomy, directly after, and 1 year after osteotomy were analyzed within the age groups using paired samples T-tests. The difference in advancement and relapse between the 2 age groups was analyzed with independent samples T-tests. Through linear regression, a possible relation between horizontal relapse and horizontal advancement

at point B and between horizontal relapse and SN-GoGn before osteotomy was tested. Furthermore, a possible relation between the age of the patients at the time of osteotomy and horizontal relapse at B was examined.

The 2 age groups were compared according to gender and duration of follow-up, and the possible difference between BSSO and BSSO in combination with Le Fort I procedure was assessed. Using a Fisher's exact test, unpaired T-test, and a Chi-square test, the differences were tested for significance. Values of $p < 0.05$ were considered statistically significant.

Intra-observer reliability was tested using intraclass correlation coefficients. The difference in measurements of 1 variable from the same radiograph was tested based on reliability.

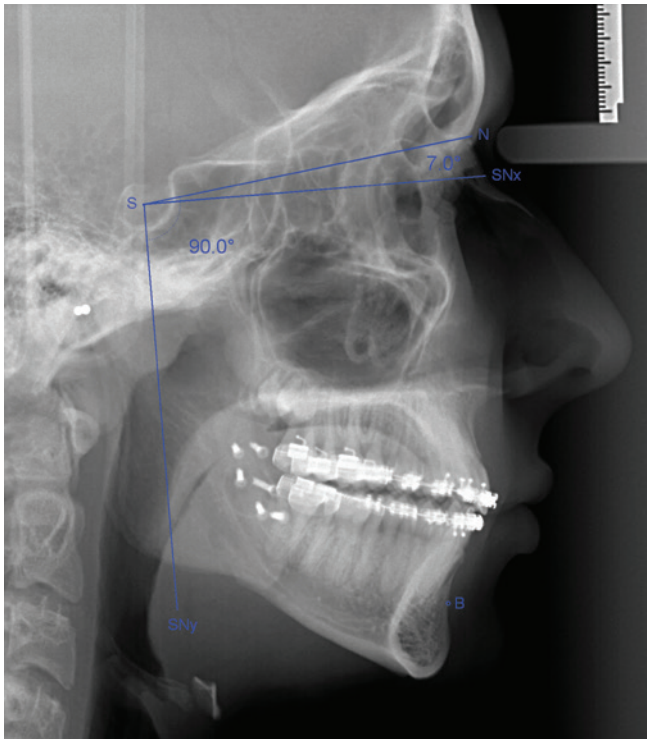

Figure 1 Post-operative lateral cephalometric radiograph shows the horizontal axis (SNx; 7° from sella-nasion line), the vertical axis (SNy) and point B, which were used to determine the stability after BSSO.

Results

Age group <18 years

In the group with patients treated before the age of 18 years, the mean horizontal relapse after a year (at point B, measured as the difference in length of BY immediately after the BSSO and the length of BY after 1 year) was 0.5 mm. This was 10.9% of the advancement, measured as the difference in length of BY immediately after osteotomy and the length before osteotomy (4.6 mm) (Table 3).

Differences in BY lengths were tested for significance. There was a statistically significant difference between pre- and postoperative BY length ($p = 0.000$), this being an approximation of the advancement caused by surgery. The difference between BY lengths immediately after osteotomy and 1 year after osteotomy was not significant ($p = 0.136$). The SNB angle decreased by 0.3 degrees 1 year following surgery. Perioperative advancement was a mean of 3.3 degrees. A significant difference was found between the pre- and postoperative SNB angle ($p = 0.000$); no statistically significant difference was found between SNB angle immediately post-operative and 1 year after osteotomy ($p = 0.199$).

Average vertical relapse after 1-year follow-up was 0.8 mm for the patients treated by single BSSO surgery.

Significant differences were found between single BSSO surgery and BSSO combined with a Le Fort I procedure in the perioperative movements of BY, BX, and SNB, respectively ($p = 0.001$, $p = 0.000$, and $p = 0.002$). A combined procedure showed a cranial and more anterior movement immediately after the operation.

At 1 year, there was no significant difference at BY, BX, and SNB between BSSO and a combined procedure ($p = 0.873$, $p = 0.826$, and $p = 0.907$). In table 3, the different results for BSSO and for BSSO combined with Le Fort I osteotomy are shown.

Age group 20–24 years

In patients aged 20–24 years, the mean horizontal relapse at point B after 1 year was 0.9 mm. This was 16.4% of the mean advancement of 5.5 mm at point B (Table 4). There was a statistically significant difference between pre- and postoperative BY length ($p = 0.000$). The difference between BY lengths immediately after the operation and 1 year postoperatively was also statistically significant ($p = 0.011$).

The SNB angle decreased by 0.4 degrees at 1 year after surgery. Mean perioperative advancement was 3.3 degrees. Significant difference was found between pre- and postoperative SNB angle ($p = 0.001$) and between SNB angle immediately after the operation and 1 year after osteotomy ($p = 0.030$).

Average vertical relapse (BX) after 1-year follow-up was 1.1 mm for the patients treated by single BSSO surgery.

Table 3 Movement and relapse of BY, BX, SNB in patients < 18 years.

	Mean movement BSSO treatment (in mm)	SD	Mean relapse after 1 year (in mm)	SD	Mean relapse after 1 year (in percentages)
Horizontal movement BY (n = 18)	+4.6	2.8	-0.5	1.3	-10.9
SRO (n = 12)	+3.2	1.7	-0.5	1.3	-15.6
SRO + Le Fort I (n = 6)	+7.3	2.5	-0.4	1.6	-5.5
SNB (n = 18)	+3.3	1.3	-0.3	0.9	-9.1
SRO (n = 12)	+2.7	0.7	-0.3	0.7	-11.1
SRO + Le Fort I (n = 6)	+4.5	1.4	-0.3	1.4	-6.7
Vertical movement BX (n = 18)					
SRO (n = 12)	+4.1	2.0	-0.8	1.3	-19.5
SRO + Le Fort I (n = 6)	-1.6	2.5	-0.6	2.2	37.5

BY, distance of point B to SNy; BX, distance of point B to SNx
+, anterior / caudal movement; –, posterior / cranial movement

Table 4 Movement and relapse of BY, BX, SNB in patients 20-24 years.

	Mean movement BSSO treatment (in mm)	SD	Mean relapse after 1 year (in mm)	SD	Mean relapse after 1 year (in percentages)
Horizontal movement BY (n = 18)	+5.5	2.7	-0.9	1.4	-16.4
SRO (n = 7)	+3.4	2.0	-0.5	1.1	-14.7
SRO + Le Fort I (n = 11)	+6.9	2.2	-1.2	1.5	-17.4
SNB (n = 18)	+3.3	1.4	-0.4	0.8	-12.1
SRO (n = 7)	+2.3	1.2	-0.2	0.5	-8.7
SRO + Le Fort I (n = 11)	+3.9	1.2	-0.6	0.9	-15.4
Vertical movement BX (n = 18)					
SRO (n = 7)	+3.5	0.8	-1.1	1.0	-31.4
SRO + Le Fort I (n = 11)	-0.9	1.6	0.2	1.0	-22.2

BY, distance of point B to SNy; BX, distance of point B to SNx
+, anterior / caudal movement; -, posterior / cranial movement

In patients aged 20 to 24 years, significant differences were found between single BSSO surgery and BSSO combined with Le Fort I procedure. The perioperative movements of BY, BX, and SNB were significantly different ($p = 0.003$, $p = 0.010$, and $p = 0.000$, respectively). A combined procedure showed a cranial and a more anterior movement immediately postoperatively. Relapse of BX after 1 year was also significantly different between single and combined procedures ($p = 0.013$); a more anterior movement was seen in combined surgery in contrast to a relapse in the single procedure. Relapse at BY and SNB was not significantly different between procedures ($p = 0.295$ and $p = 0.271$).

Comparisons between age groups

The duration of follow-up, gender, and number of patients treated with BSSO or a combination with Le Fort I procedure were compared between both age groups. No significant differences were found ($p = 0.246$, $p = 0.443$, and $p = 0.095$, respectively).

For perioperative horizontal advancements, no significant differences were found among the age groups between preoperative and immediately postoperative BY lengths ($p = 0.259$). There was also no significant difference in the horizontal relapse at point B after 1 year between age groups ($p = 0.359$).

The advancement and relapse of SNB and BX were compared between age groups as well. No significant difference was found in any of the variables ($p > 0.05$).

SN-GoGn appeared to have no influence on the horizontal relapse after 1 year. In addition, the amount of advancement at point B after BSSO and age did not have significant influence on the horizontal relapse.

In all patients, the function of the inferior alveolar nerve was tested during follow-up. Hypoesthesia in the lip and chin area was documented. None of the patients experienced hypoesthesia before BSSO. After 1 year, 2 patients in both age groups reported mild unilateral hypoesthesia.

The intraclass correlation coefficient was higher than 0.983 in all variables (SNA, SNB, BY, BX, SN-GoGn, and SPPL-MPL) before, immediately after, and 1 year after BSSO. This implies that good intra-observer reliability was established.

Discussion

In correcting a skeletal class II malocclusion, the stability of the chosen procedure is an important factor. The relapse percentage of 10.9% found in this study shows that sagittal split osteotomy is a reliable procedure for advancement of the mandible

during adolescence. To the authors' knowledge, there have been no recent reports on the stability of mandibular advancement using BSSO during adolescence. Older reports on stability of BSSO during adolescence date from the 70's and 80's, as mentioned in the introduction. The higher relapse percentages found in these studies could be explained by differences in technique, as these studies were based on mandibular advancement with wire fixation, which is a known less stable method [16].

The control group showed a relapse percentage of 16.4% after 1 year; this percentage is presumably representative of the relapse in adult patients at our center. In the last 10 years, studies have reported inconsistent 1-year relapse percentages for mandibular advancement performed using BSSO in adult patients. Several studies show 20% to 30% relapse at B point after 1 year [5,6,17]. One study showed a relapse of only 1% after 1 year [18] and one an even more anterior movement in the first year after osteotomy [19]. The relapse percentage found in this study in the adult patient group is approximately equal to recently described results in the literature.

Although not significant, the difference in relapse percentages between both age groups, 10.9% vs. 16.4%, tended to favor the adolescent group. Furthermore, the difference in BY length immediately and 1 year after the operation was significant in the age group 20–24 years and not significant in the adolescence group. Groups were comparable with respect to duration of follow-up, gender, perioperative advancement, and the number of patients treated with BSSO or a combination with a Le Fort I procedure. The apparent difference in relapse could be explained by the fact that perioperative movement is in the same direction as postoperative growth. A part of the relapse is compensated by growth of the mandible after osteotomy; thus, young age seems to partly prevent relapse. Although, not significant, the greater amount of Le Fort I procedures (with therefore more mandibular advancement) in the control group could also explain the difference in relapse.[20]

The influence of the mandibular plane angle on relapse has been shown in several studies [6,20]. In our study, no relationship was detected between preoperative mandibular plane angle, measured as the SN-GoGn angle, and the horizontal relapse following surgery.

The patients included in this study had relatively small advancements. In series with adult patients, results have been shown to be less stable after greater advancement [20]. Further, the number of patients in this study was relatively small. However, the results of the study indicate that BSSO seems to be a stable procedure during adolescence for patients who require normal advancement. If this patient number increases in the future, the results of a larger patient population can be analyzed.

There are many advantages of correcting mandibular retrognathia at a young age. The problems experienced because of mandibular retrognathia, such as impaired

speech, discomfort in chewing, malocclusion, damage of the periodontium caused by palatal interdigitation, and pain, are resolved at a young age by advancing the mandible. A relationship between higher age and more frequent permanent damage of the inferior alveolar nerve is reported in several studies [15,21,22], presumably because of bad regeneration of the damaged nerve with increased age. Surgery at a young age may prevent permanent damage of the inferior alveolar nerve in many cases. Additionally, facial aesthetics will improve after the procedure. The positive implications on social functioning and wellbeing, relevant issues in adolescence, have been described explicitly [23,24].

Conclusion

Our results indicated that a BSSO performed during adolescence is a relatively stable procedure. The presumed difference in relapse rates between surgery during adolescence and in adults is not supported. Therefore, the results of this small series suggest that BSSO can be performed in adolescence as well. To obtain more definitive conclusions, a prospective, randomized controlled trial is recommended between both techniques for analyzing stability and complications in both age groups.

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