The Functional Long-Term Results After Bilateral Sagittal Split Osteotomy (BSSO) With and Without a Condylar Positioning Device

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Purpose: The goal of this retrospective study was to examine whether utilization of condylar positioning devices in bilateral sagittal split osteotomy leads to long-term benefits for temporomandibular joint function as compared with the manual positioning technique.

Patients and Methods: The joint function of 49 patients (98 joints) who underwent bilateral sagittal split osteotomy or bimaxillary osteotomy at the University Hospital of Aachen between 1993 and 2003 was analyzed by recording joint movements with axiography supported by clinical examination of the temporomandibular joint. In 10 patients out of 28 with mandibular advancement and in 10 out of 21 with mandibular setback the Luhr positioning device was used intraoperatively to reproduce the condylar position. The joints of the remaining patients were positioned manually. The received data were statistically evaluated by using unrelated *t* test at $P = .05$.

Results: In mandibular advancement the manually positioned group showed significantly less signs of temporomandibular disorders, while there were slight advantages in axiographically measured joint track lengths for the patients who were operated with positioning devices. After mandibular setback surgery clinical analysis as well as axiography presented comparable results in both groups.

Conclusion: The use of a positioning device did not provide a better functional outcome long term in either mandibular advancement or setback surgery. With the manual positioning technique, an at least equally good temporomandibular joint function was attained.
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Bilateral sagittal split osteotomy (BSSO), according to Obwegeser[1] and Dal Pont,[2] is a well-established standard method in maxillofacial surgery and probably the most frequently used technique for total osteotomy of the mandible.[3] Currently, apart from a stable skeletal outcome and a harmonic soft tissue profile, consideration of the postsurgical temporomandibular joint (TMJ) function is of increasing interest.[4,5] Indeed, the functional result is inextricably linked with the surgical technique, particularly as far as the intraoperative positioning of the condyle is concerned. It is well known that alterations in condyle position from surgery not only can lead to malocclusion associated with the risk of an early relapse,[5-8] but may also favor the development of signs and symptoms of temporomandibular disorders (TMD).[5,9-13] For these reasons, several positioning devices have been proposed and applied over the past 30 years.[6,14-16] One of the most popular and widely used methods was introduced by Luhr in 1985.[5,17] However, because there is a lack of evidence-based data, it remains controversial whether the application of positioning appli-

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Table 1. PATIENTS WITH MANDIBULAR ADVANCEMENT

Positioning Device	Advancement *Without* Maxillary Osteotomy	Advancement *With* Maxillary Osteotomy	Advancement Total
Yes	8	2	10
No	16	2	18
Total	24	4	28

Gerressen et al. Long-Term Results After BSSO. J Oral Maxillofac Surg 2006.

ances could result in better functional long-term outcomes.[18,19]

We performed a retrospective analysis of our clinical experience to investigate TMJ function after BSSO with and without the use of condylar positioning devices.

Patients and Methods

Forty-nine patients (98 joints) who had undergone BSSO or bimaxillary osteotomy in our institution (Klinik für ZMKPG des Universitätsklinikum der RWTH Aachen, Germany) between 1993 and 2003 and fulfilled the inclusion criteria were accepted into the study. In all cases osteosynthesis of the mandibular segments was performed by using miniplates or positional screws. Neither the preoperative joint function nor the magnitude of the movement exerted an influence on whether a positioning appliance was used or not. In fact, it was based on the preference of the referring orthodontists of whom some recommended the apparatus positioning in all of their patients. The remaining patients were positioned manually. Only patients who had undergone surgery between 6 and 120 months before analysis were included. Twenty-eight patients had received a BSSO for mandibular advancement combined with a Le Fort I osteotomy in 3 patients and with an anterior maxillary segmental osteotomy in 1 patient (Table 1). In 10 of these patients, positioning plates according to Luhr (Stryker Leibinger, Freiburg, Germany) were used intraoperatively to reproduce the condylar position, whereas the joints of the remaining 18 patients were positioned manually. To reveal structural equality of the apparatively and manually positioned groups, they were compared by unrelated t test at $P = .05$ with regard to patients' age, postoperative time, and change of the SNB angle and WITS appraisal in the lateral cephalogram representing the magnitude of surgical correction.

Mandibular setback was carried out in 21 patients; of those, 10 received a surgical correction of the maxilla simultaneously (9 Le Fort I osteotomies, 1 posterior maxillary segmental osteotomy) (Table 2). The Luhr condylar positioning device was used in 10 patients, while in the remaining 11 patients the manual positioning technique was applied. Again, structural equality of the manual and the apparative groups with regard to the above-mentioned criteria was ensured by unrelated t test at $P = .05$.

For all patients the post-treatment examination consisted of an axiography by means of the Cadiax Compact system (GAMMA Gmbh, Klosterneuburg, Austria) (Fig 1) and a manual functional analysis as described by Bumann and Lotzmann.[20] First, the limit movements of both joints (ie, protrusion, mediotrusion right, mediotrusion left, and open/close) were recorded axiographically with a paraocclusal clutch in each subject. Each movement was repeated until a reliable result was reached. The registered data were transferred to a personal computer and processed using GAMMA Dental Software for Windows (GAMMA Gmbh) (Fig 2). This way, 5 values were determined for each condyle path so that, on balance, we collected 15 values to characterize the function of each joint. In open/close and protrusion movement, joint track length (JTL), sagittal condylar inclination angle (SCI) taken at 1 mm, 3 mm, and 5 mm JTL ($SCI_{1\ mm}$, $SCI_{3\ mm}$, $SCI_{5\ mm}$), and transversal condylar inclination angle (TCI) taken at maximum JTL (TCI_{max}) were recorded. For descriptive analysis of the mediotrusion path, JTL, SCI taken at 1 mm and 3 mm, JTL and TCI taken at 3 mm, and maximum JTL were determined. As standard distribution could be shown by boxplot analysis, the data of the apparatus and manual groups were statistically compared using unrelated t test at $P = .05$.

Finally, from axiographic data collected and the results of the manual functional analysis, an additive temporomandibular disorder index (TMD-Index) was formed for each joint. The clinical symptomatic component of the TMD-Index arose out of the pathologic findings in functional analysis, which were given points according to defined criteria.[21] Known history of TMD was taken into account with a suitable point deduction. As a functional component, selected axiography was transformed into point values that were

Table 2. PATIENTS WITH MANDIBULAR SETBACK

Positioning Device	Setback *Without* Maxillary Osteotomy	Setback *With* Maxillary Osteotomy	Setback Total
Yes	6	4	10
No	5	6	11
Total	11	10	21

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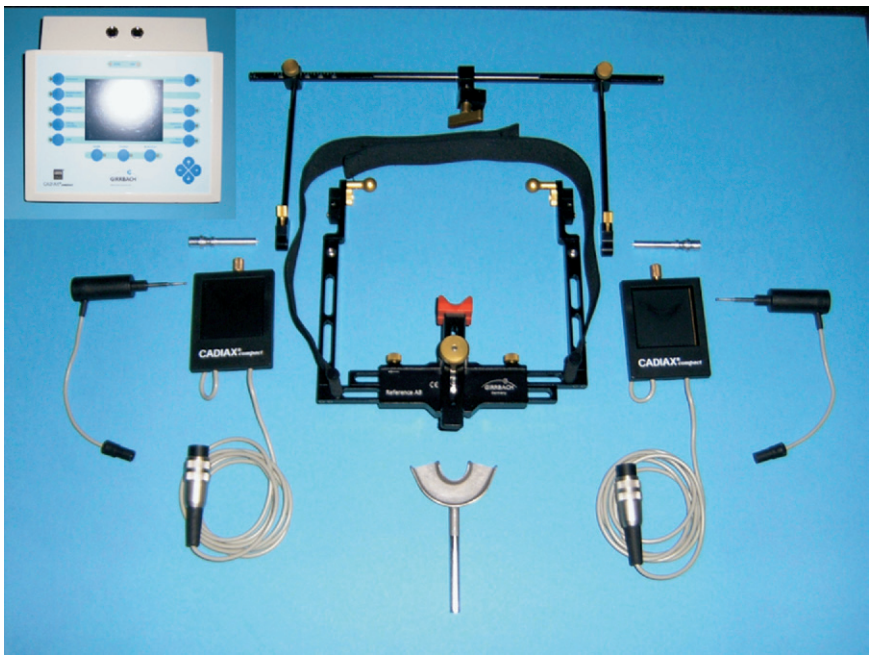

FIGURE 1. Overview of all components of the Cadiax compact system (electronic box is reduced in size).

Gerressen et al. Long-Term Results After BSSO. J Oral Maxillofac Surg 2006.

incorporated into the TMD-Index (Table 3). Thus, finally, the sum of point values of the clinical symptoms combined with the functional component yielded the additive TMD-Index used for further analysis. Standard distribution could be proven by boxplot analysis and the TMD-Indexes of the apparatively and manually positioned groups were statistically compared by unrelated *t* test at $P = .05$.

Results

In mandibular advancement, the axiography data revealed a statistically significant difference between the manual and the apparatus groups in 2 of the 15 characteristic values (Table 4). The JTL in protrusion (Fig 3) and mediotrusion presents significantly higher in the group with positioning devices. In accordance with the 95% confidence interval for the difference in mean values, 10 of the remaining 13 characteristic values must be assumed equal. In 3 values there was no significant difference between the 2 groups, but the confidence intervals are too big to allow concluding equality of the data directly. These 3 values are the transversal condylar inclination angles for open/close and mediotrusion. The TMD-Index of the manually posi-

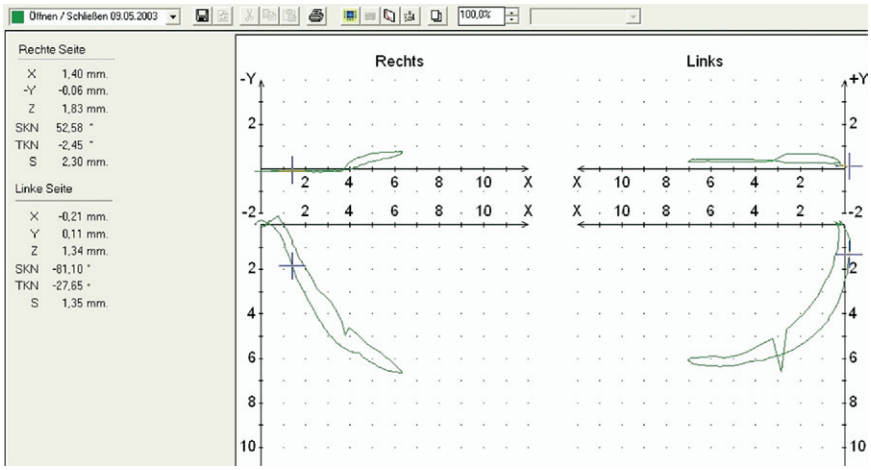

FIGURE 2. Axiographic tracks for open/close after mandibular advancement without positioning devices as displayed on a personal computer; transversal plane on the top, sagittal plane at the bottom, data corresponding to the position of the crosses on the left side.

Gerressen et al. Long-Term Results After BSSO. J Oral Maxillofac Surg 2006.

Table 3. POINTS SYSTEM AND ASSESSING CRITERIA FOR AXIOGRAPHY

Joint Track	Criteria	Reference Values[22-24]	Differing Findings
Protrusion	Joint track length	10+/−3 mm	1 P
	$SCI_{3\,mm}$	53+/−15°	1 P
	General impression	Regular	0.25-1 P
Open/close	Joint track length	14+/−5 mm	1 P
	$SCI_{3\,mm}$	53+/−15°	1 P
	General impression	Regular	0.25-1 P
Mediotrusion	Joint track length	11+/−4 mm	1 P
	$SCI_{3\,mm}$	60+/−15°	1 P
	$TCI_{3\,mm}$	7+/−4°	1 P

Gerressen et al. Long-Term Results After BSSO. J Oral Maxillofac Surg 2006.

tioned group shows a significantly better result compared with the group with positioning devices (Fig 4). Thus, patients in the manual group have significantly fewer joint disorders and a clinically better joint function. In summary, in the positioning device group minimal advantage arises regarding the axiographically determined data, whereas the group without positioning devices offers distinct benefits concerning the TMD-Index.

In patients with mandibular setback, 4 of the 15 determined axiographic values differ significantly (Table 5). These include the 3 SCI in protrusion movement being higher in the manual group and the SCI taken at 1-mm track length in open/close favoring the apparatus group. Nine of the remaining 11 characteristic values, among them all features of the mediotrusion paths, present equally (corresponding to the calculated confidence intervals). In contrast, the SCIs taken at 3-mm and 5-mm track length in open/close neither differ significantly nor do the confidence intervals for the difference in mean values indicate their equality. The analogous applies to TMD-Index. The group with manual condylar positioning shows a better result with regard to the mean value of TMD-Index, but the difference compared with the apparatus group is not statistically significant (Fig 5). Thus, in mandibular setback both groups approximately provide comparably good results concerning axiography data as well as TMD-Index.

Table 4. RESULTS FOR MANDIBULAR ADVANCEMENT

Advancement Positioning Device		Mean Value		Significant Difference	Data Statistically Equal
		Yes	No		
Protrusion	JTL/mm	**7.96**	5.64	Yes	No
	$SCI_{1\,mm/°}$	45.32	43.68	No	Yes
	$SCI_{3\,mm/°}$	46.59	45.19	No	Yes
	$SCI_{5\,mm/°}$	43.55	43.08	No	Yes
	$TCI_{max/°}$	1.54	1.06	No	Yes
Mediotrusion	JTL/mm	**8.06**	5.91	Yes	No
	$SCI_{1\,mm/°}$	45.35	44.08	No	Yes
	$SCI_{3\,mm/°}$	48.31	47.16	No	Yes
	$TCI_{3\,mm/°}$	13.32	14.59	No	No
	$TCI_{max/°}$	13.56	15.35	No	No
Open/close	JTL/mm	9.44	8.25	No	Yes
	$SCI_{1\,mm/°}$	45.37	45.01	No	Yes
	$SCI_{3\,mm/°}$	48.60	48.57	No	Yes
	$SCI_{5\,mm/°}$	45.75	46.99	No	Yes
	$TCI_{max/°}$	2.46	2.52	No	No
TMD-Index		10.70	**6.74**	Yes	No

NOTE. Significantly better results are printed in bold.

Gerressen et al. Long-Term Results After BSSO. J Oral Maxillofac Surg 2006.

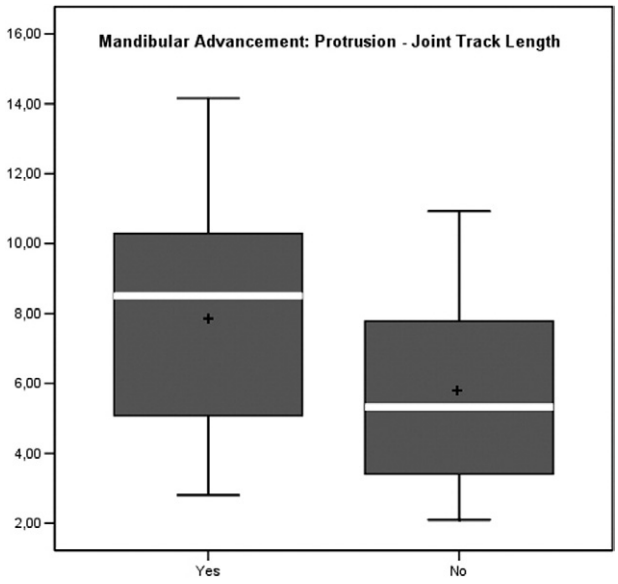

FIGURE 3. Joint track lengths (JTL) for the group with ("Yes") and without ("No") positioning devices in protrusion movement after mandibular advancement.

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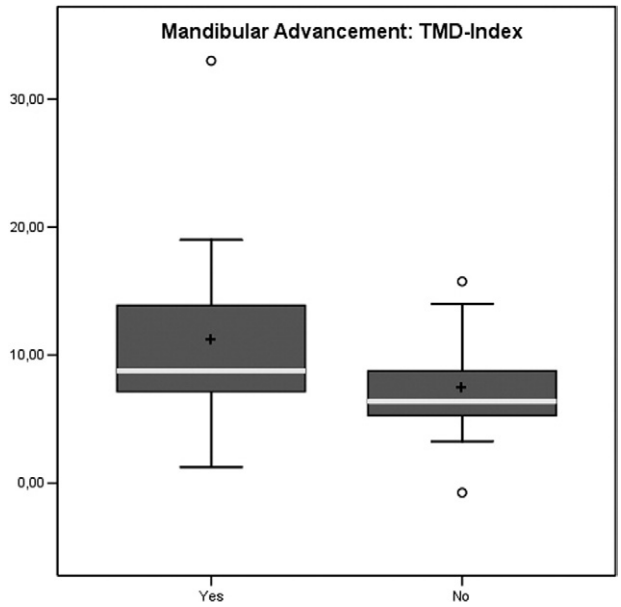

FIGURE 4. Comparison of TMD-Indexes for the apparative ("Yes") and the manual ("No") group after mandibular advancement.

Gerressen et al. Long-Term Results After BSSO. J Oral Maxillofac Surg 2006.

Discussion

Several studies have investigated the use of positioning devices in orthognathic surgery to assess their role in prevention of changes in condyle position and in functional outcome,[4,12,18,25-29] although this issue remains controversial. Helm and Stepke[4] performed a prospective study on 30 patients with an angle Class III malocclusion who underwent a bimaxillary osteotomy using the Luhr positioning device. The pre- and postoperative joint tracks were compared axiographically, and a pathologic shortening could be observed after surgery in

Table 5. RESULTS FOR MANDIBULAR SETBACK

Setback Positioning Device		Mean Value		Significant Difference	Data Statistically Equal
		Yes	No		
Protrusion	JTL/mm	6.05	7.51	No	Yes
	$SCI_{1\ mm/°}$	39.40	**47.34**	Yes	No
	$SCI_{3\ mm/°}$	42.97	**50.24**	Yes	No
	$SCI_{5\ mm/°}$	42.11	**46.58**	Yes	No
	$TCI_{max/°}$	0.99	1.80	No	Yes
Mediotrusion	JTL/mm	7.76	8.14	No	Yes
	$SCI_{1\ mm/°}$	48.13	48.05	No	Yes
	$SCI_{3\ mm/°}$	48.60	50.55	No	Yes
	$TCI_{3\ mm/°}$	9.46	9.02	No	Yes
	$TCI_{max/°}$	13.84	13.81	No	Yes
Open/close	JTL/mm	9.14	8.68	No	Yes
	$SCI_{1\ mm/°}$	**59.68**	18.93	Yes	No
	$SCI_{3\ mm/°}$	60.25	43.50	No	No
	$SCI_{5\ mm/°}$	56.27	47.07	No	No
	$TCI_{max/°}$	2.15	3.96	No	Yes
TMD-Index		7.76	5.51	No	No

NOTE. Significantly better results are printed in bold.

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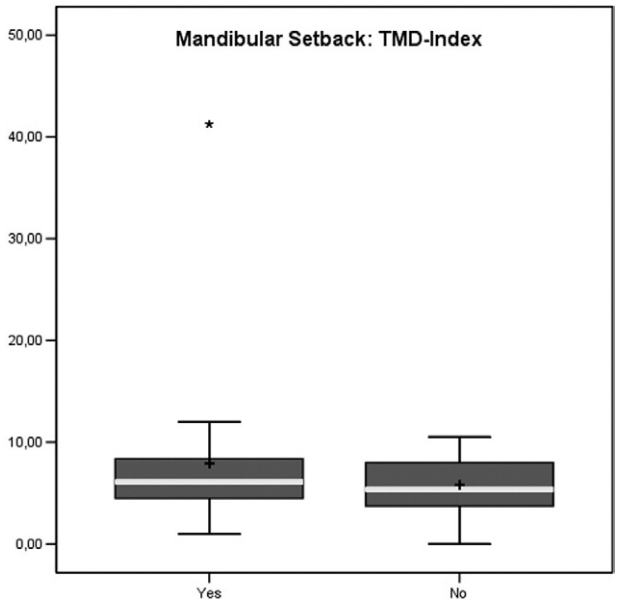

FIGURE 5. Comparison of TMD-Indexes for the apparative ("Yes") and the manual ("No") group after mandibular setback.

Gerressen et al. Long-Term Results After BSSO. J Oral Maxillofac Surg 2006.

only 1 case in which the effective functioning of the positioning appliance was deemed responsible. These findings are reinforced by several other examinations demonstrating that the use of positioning appliances especially in bimaxillary surgery results in a significant reduction of TMD signs and symptoms.[27,28]

On the other hand, it has also been reported that positioning devices do not always guarantee the preservation of the preoperative condyle position.[30] This observation is not surprising as many transmission errors can occur, from recording centric relation to intraoperative fixation of the fragments. Even if the preoperative position of the condyles is accurately preserved, it is dubious whether this position is the most favorable and thus desirable in regard to physiologic TMJ function and skeletal stability. Because BSSO is an elementary intervention in the biomechanics of the mandible, including all attaching muscles and ligaments, the preoperative condyle position does not have to be the one with the least TMJ derangements and best possible skeletal stability postoperatively.[12,31]

In the present study, we did not observe any distinct advantage for the apparatively positioned group, neither in mandibular setback nor in advancement surgery. Detailed analysis of the axiographic tracks only yielded marginal differences between both positioning techniques. On the contrary, the TMD-Indexes, which are of great relevance for clinical joint function and the patients' subjective well-being, provide better results in the manual groups with statistically significant difference in mandibular advancement only (Tables 4 and 5). In fact, in the positioning device group, after mandibular advancement, the standard deviation of the TMD-Indexes was more than twice as high (indicating their inhomogeneous distribution) and therefore the basic problem of the positioning technique. Relying on the correct performance of positioning devices does not necessarily prevent extreme malpositions of the condyles, including all negative consequences that may occur with a higher probability compared with the manual technique (which is constantly under the operator's control).

In conclusion, our data do not suggest that the final operative outcome using positioning devices would justify the considerable additional effort before and during surgery. In general, we agree that the basic idea of positioning appliances is logical and almost ingenious, but manual technique in experienced hands can provide at least equally good results.

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