Original Study

AN INVESTIGATION ON BONE DEFORMITIES AND CLINICAL SYMPTOMS OF TEMPOROMANDIBULAR JOINT AFTER ORTHOGNATHETIC SURGERY IN CLASS III PATIENTS

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ABSTRACT

Introduction: Maxillary deficency or Mandibular prognathism or combination of them causes skeletal class III malocclusion in patients. Bilateral Sagittal Split Osteotomy (BSSO) is one of the common methods for the treatment of this malocclusion and it can cause multiple effect on TemproMandibularJoint (TMJ). The aim of this study was to evaluate the effect of BSSO on class III patients after the surgery.

Method: In this study, 25 patients who underwent (BSSO) for the Treatment of skeletal Class III were with CBCT radiographs of TMJ and physical examination records before and six months after surgery, were evaluated . Data were analyzed with the software SPSS16 and paired t-test .

Results: The results showed that the axial angle of the left and right condyle and condylar inclination on both sides has been reduced but this reduction was not statistically significant. Both the intercondylar distance and the coronal angle condyle also increased, but these changes were not statistically significant. Also the joint spaces, the anterior joint space reduced on both sides and posterior joint space increased in both sides but changes were only significant on the right side (P = 0.039). Sagittal condylar angle and the upper joint spaces also were not statistically significant on both sides. In clinical examinations maximum mouth opening, lateral movements and protrusive also decreased but this reduction was not statistically significant.

Conclusion: Our study shows that surgery in patients with skeletal Class III using BSSO method didn't have significant effect on the position of the condyle in glenoid fossa and symptoms of TMD.

Key words: Orthognathic surgery, Bilateral Saggital Split Osteotomy, CBCT, class III malocclusion

Introduction

Growth and development of each person is influenced by heredity and environment, and if any of these two factors is impaired, dentofacial deformity will occur. So, these anomalies are divided into two categories: congenital or acquired. Pattern of inheritance, such as family history, can cause a prognathic mandible or a retrognathic maxilla. Environmental factors include trauma and changes in forces exerted on the bones of the face and Temporomandibular joint (TMJ) ankylosis. Mandibular growth or maxillary deficiency or both of them cause Skeletal Class III malocclusion in patients in patients with reverse overjet and protruding lips. Dentofacial disorders affect occlusion, temporomandibular joint and its related structures. According to the morphology studies, the skeletal can cause symptoms of TMD.[1] Now, malocclusion can be treated using orthodontic and correction surgery.[2]

At first, orthosurgery surgery was performed by correcting mandible, but now it is simultaneously performed on both jaws in 40% of class III patients.[3] This surgery affects the position of the condyle and the occlusion. According to the some studies, these changes can improve symptoms of TMD, or in some cases worse them. According to the conflicting results between articles that show improvement of TMD[4] and sometimes an increase in stress in the TM[5] and sometimes no improvement or no effect on joint problems,[6,7] this study aims to investigate bone deformities and clinical symptoms of temporomandibular joint after orthognathic surgery in class III patients.

According to changes in joint space and the position of the condyle and the comparison with the pre-operative mode as well as a physical examination about the mouth opening, joint sound and muscle tenderness before and after surgery, the present study investigates the changes which occur by this surgery in joint space and the relationship between condyle and Articular eminence as well as the patient's clinical symptoms.

Materials and Methods

In this study, which is retrospective cross-sectional, 25 patients who referred to Mashhad Dental School and underwent Bilateral Sagittal Split Osteotomy (BSSO) for the treatment of class III skeletal were selected.

Participants

Patients who underwent Bilateral Sagittal Split Osteotomy (BSSO) for the treatment of class III skeletal and used the Cone-beam Computed Tomography (CBCT) for the diagnosis of temporomandibular joint disorder before and six months after surgery were selected.

Inclusion and exclusion criteria:

- Inclusion criteria
  - patients with skeletal Class III malocclusions in the age range of 18-30 years
  - history of BSSO surgery
  - Cone-beam Computed Tomography (CBCT) for the diagnosis of temporomandibular joint disorder
  - Recording patients' clinical examinations before and after surgery
- Exclusion criteria
  - Severe asymmetry
  - Underlying disease

- Syndrome

According to patient records, a check list was prepared including two parts: demographic data and clinical examination. According to demographic data, age, gender, orthodontists name were extracted from the patient records. According to the clinical examination, some data, such as maximal mouth opening, presence or absence of joint sound and tenderness to touch, were extracted from the patient records.

Twenty Five patients who underwent the LeFort I type maxillary osteotomy (LFI), the bilateral sagittal split osteotomy of the mandible (BSSO) for the treatment of class III skeletal were selected. The patients were in the age range of 18-30 years old, including 15 women and 10 men with an average age of 23.2 ± 2.7 years. The patients had no severe asymmetry, underlying diseases and syndromes, and were still under orthodontic treatment after surgery.

Radiographic Image Analysis

One day before surgery and six months later, Cone-Beam Computed Tomography (CBCT) was prepared for both sides of the TMJ to assess radiographic joint. CBCT images were obtained at closed mouth with upright position and the Frankfort Horizontal (FH) plane was parallel to the ground. CBCT device was used based on the following specifications at the time of 8.5 seconds of radiation.

CBCT: Promax, Finland, 2013
MAX KVP: 75 kV
MAX M.A: 12 MA
Slice thickness: 0.2 mm

In sagittal, coronal and axial planes, 15 variables in the [Table 3] were examined with respect to 25 reference points listed in the tables 1 and 2. Yoon *et al*. conducted a study entitled "Clinical changes of TMD in class III patients" to investigate anatomical landmarks in CBCT.[7] [Figures 1,2,3]. In addition, the changes in the longitudinal axis of condylar inclination were investigated. The angle of condylar axis was measured based on the passing line of the anterior and posterior joint eminence. All variables were measured by one person and two times within two weeks.

Plane of Reference	Definition
Horizontal Reference Plane (HRP)	Frankfurt plane or planes between Po_{RT}, Or_{RT}, Po_{LT}
Sagittal Reference Plane (SRP)	Mid-sagittal plane or imaginary plane perpendicular to the FH plane and the transmission of BANA
Coronal Reference Plane (CRP)	Na vertical plane, or plane perpendicular to FH and mid-sagittal plane which passes through Na

Table 1: Reference Plane.

Reference Landmarks	Definition
NA	The most anterior point in Naso frontal in the sagittal plane
S	The midpoint of the pituitary fossa
BA	The midpoint of the anterior border of superego magnum
F_{RT}/F_{LT}	The uppermost point (left / right) of glenoid fossa
CO_{RT}/CO_{LT}	The uppermost point (left / right) of condyle
L_{RT}/L_{LT}	The most posterior point of the upper level (left / right) of condyle
PO_{RT}/PO_{LT}	The uppermost point (left / right) of outer ear hole
PO'_{RT}/PO'_{LT}	The lowermost point (left / right) of outer ear hole
AM_{RT}/AM_{LT}	The lowermost point (left / right) of articular eminence
MDP_{RT}/MDP_{LT}	The most middle point (left / right) of disk pole
DDP_{RT}/DDP_{LT}	The most distal point (left / right) of disk pole
CON_{RT}/CON_{LT}	The most middle point (left / right) of condylar neck in the coronal plane
OR_{RT}/OR_{LT}	The lowermost point (left / right) of Infra orbital margin
D_{RT}/D_{LT}	The midpoint of the posterior condyle and the Po-Am line (left and right)

Table 2: Reference Landmarks

Plane	Measurement	Definition
Sagittal	$Po'_{Rt.}$-$D_{Rt.}$/$Po'_{Lt.}$-D_{Lt}	Distance between the Po '& D
	$F_{Rt.}$-$Co_{Rt.}$/$F_{Lt.}$-Co_{Lt}	Distance between the F & Co
	$Am_{Rt.}$-$L_{Rt.}$/$Am_{Lt.}$-L_{Lt}	Distance between Am & L
	$Po'_{Rt.}$-$Am_{Rt.}$/$Po'_{Lt.}$-Am_{Lt}	Distance between the Po '& Am
	Sagittal condylar angle $_{Rt.}/_{Lt}$	Angle between the Co-Lline & Po'-Amline
Axial	Axial angle between the left and right condyle	Angle between MDP-DDP line and Sagittal reference plane
	Distance between the condyle	Distance between the left and right condyle
Coronal	Coronal condylar angles (left and right)	Angle between the CoN-Co line and horizontal reference plane

Table 3: Definitions of distances and angles measured in CBCT images.

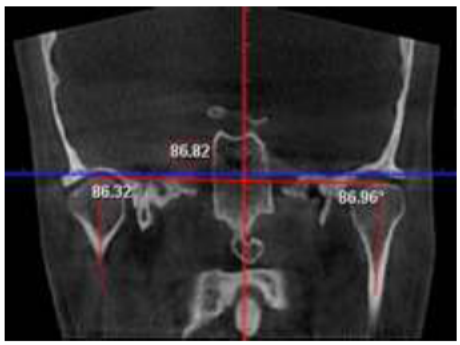

Figure 1: Measuring coronal condylar angles and the distance between the condyles

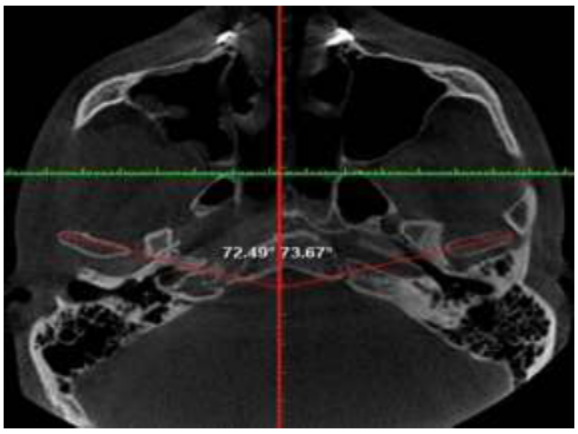

Figure 2: Measuring the axial condylar angle

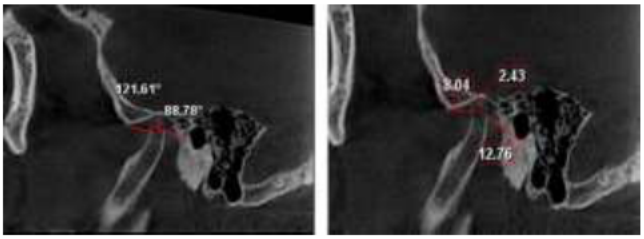

Figure 3: Measuring the sagittal condyle angle, condyle inclination and joint spaces

Clinical Examination

Data were collected using the examinations in patient records based on self-report as well as the physical examination before surgery and 6 months later. In the clinical examination, joint pain, temporomandibular during operation (chewing or opening the mouth), joint sound during opening and closing, maximal mouth opening and lateral and protrusive movements were considered.

Patients were asked about subjective changes in joint based on the presence or absence. Clinical examinations were performed using Diagnostic Criteria for Temporomandibular Disorders. For the clinical examination, the criteria for maximal mouth opening,[8] [Figure4] the following items were considered: presence or absence of joint sound and joint tenderness to touch during before and after surgery.[9] [Figure 5]

Figure 4: Measuring maximal mouth opening and the lateral movement of the mouth

Figure 5: Touching the posterior and lateral part of tempodibular joint

Method of Data Collection

The field method was used to collect the data and the instrument was a questionnaire.

Sample Size

According to the inclusion criteria of the patients, 25 patients with clinical and radiographic evidence were studies.

Results

The patients were in the age range of 18-27 years old, including 15 women (60%) and 10 men (40%) with an average age of 23.2 ± 2.7 years. They were compared in terms of the variables before and after surgery listed in the following tables. For the analysis of the results, the normal distribution of data was examined using the Shapiro-Wilk test. Twelve variables with non-normal distribution are listed in the table below: [Table 4]

	Variable	Statistics	Degrees of Freedom	p-value
Joint Space Before Surgery	Upper right	0.606	25	<0.001
	Upper left	0.719	25	0.001
	Right posterior	0.806	25	0.006
	Left posterior	0.805	25	0.006
Joint Space After Surgery	Left anterior	0.823	25	0.001
	Upper right	0.552	25	<0.001
	Upper left	0.688	25	<0.001
	Right posterior	0.772	25	0.002
	Left posterior	0.809	25	0.007
	left sagittal angle	0.482	25	<0.001
	Maximal mouth opening	0.699	25	<0.001
	Left movement	0.792	25	0.004

Table 4: Non-normal variables based on the Shapiro-Wilk test (before and after surgery)

As displayed in Table 5, the axial angle of the left and right condyle and condylar inclination on both sides was reduced, and this reduction was not statistically significant. In addition, condylar coronal angle on both sides and the distance between the condyles increased, and this increase was not statistically significant.

	Variable	N	Mean	SD	Min.	Max.	Range of variation	Median	Paired t-test results
Axial Condyle Angle	Right before surgery	25	73.59	6.15	62.63	82.84	20.21	74.31	t=1.66; p= 0.120
	Right after surgery,	25	73.38	6.03	62.17	82.36	20.19	74.27	
	Left before surgery	25	73.91	6.66	63.75	85.16	21.41	72.89	t=1.38; p= 0.191
	Left after surgery	25	73.41	6.35	63.68	89.84	21.21	72.66	
Condylar Coronal Angle	Right before surgery	25	80.83	5.60	69.83	88.18	18.35	80.67	t=0.57; p=0.578
	Right after surgery	25	80.91	5.39	70.56	88.49	17.93	81.14	
	Left before surgery	25	80.52	5.07	70.54	87.36	16.82	81.62	t=0.55; p=0.589
	Left after surgery	25	80.65	5.12	70.68	87.51	16.83	81.80	
Distance between the Condylar	Before surgery	25	99.05	6.04	86.82	106.8	19.98	100.8	t=0.53; p=0.604
	After surgery	25	99.17	6.27	86.20	106.8	20.67	1	
Condylar Sagittal Angle	Right before surgery	25	144.5	9.64	125	7	31.17	100.9	t=0.16 p=0.672
	Right after surgery	25	3	9.08	128.4	156.1	27.80	146.8	
	Left before surgery	25	144.8	8.68	3	7	29.65	8	z=1.16 p=0.245
	Left after surgery	25	7	36.81	130	156.2	147.54	143.3	
Inclination	Right before surgery	25	146.9	9.19	120.31	3	32.55	6	t= 0.659 p=0.521
	Right after surgery,	25	8	9.20	74.32	159.6	32.63	149.1	
	Left before surgery	25	138.6	9.69	74.30	5	34.84	7	t= 0.58 p=0.572
	Left after surgery	25	88.47	9.49	71.23	160.8	34.72	149.1	

Table 5: Mean, standard deviation, minimum, maximum, range of variation, median, joint angles before and after surgery and the results of statistical tests

The anterior joint space decreased and the posterior joint space increased on both sides. Only changes in the posterior joint space on the right were significant. The upper joint space and the angle of the sagittal condyle on both sides had no significant changes. [Table 6]

	Variable	N	Mean	SD	Min.	Max.	Range of Variation	Median	Paired t-test results
Anterior joint space	Right before surgery	25	8.74	0.61	7.64	9.90	2.26	8.63	t= 1.26 p =0.229
	Right after surgery	25	8.57	0.92	6.05	9.90	3.85	8.63	
	Left before surgery	25	8.48	0.63	6.85	9.52	2.67	8.60	z= 0.47 p =0.637
	Left after surgery	25	8.43	0.72	6.40	9.43	3.30	8.56	
Upper joint space	Right before surgery	25	2.76	1.85	1.60	8.77	7.17	2.00	z= 0.63 p =0.530
	Right after surgery	25	2.79	1.87	1.60	9.00	7.40	2.10	
	Left before surgery	25	3.01	1.69	1.65	8.10	6.45	2.52	z= 1.04 p =0.300
	Left after surgery	25	2.89	1.75	1.60	8.25	6.56	2.13	
Posterior joint space	Right before surgery	25	10.79	2.41	4.12	13.68	9.56	11.33	z= 0.206 p =0.039
	Right after surgery	25	11.11	2.30	4.33	13.80	9.47	11.54	
	Left before surgery	25	10.48	2.36	3.62	13.79	10.17	11.37	z= 0.25 p =0.802
	Left after surgery	25	10.50	2.30	4.00	13.10	9.10	11.29	

Figure 6: Mean, standard deviation, minimum, maximum, range of variation, median, joint angles before and after surgery and the results of statistical tests

In clinical examinations, maximal mouth opening, and lateral and protrusive mandibular movements were reduced, but this reduction was not statistically significant. [Table 7] According to the physical examination, maximal mouth opening, lateral and protrusive movements decreased compared to before surgery, but this reduction was not statistically significant. In addition, 19 patients (76%) (12 women and 7 men) had the symptoms of TMD, including clicking, disc dislocation with reduction and morphologic changes in the preoperative radiograph. 9 patients (5 women and 4 men) had previous symptoms after surgery. No pain or crepitus was observed.

Variable	N	Mean	SD	Min.	Max.	Range of Variation	Median	Paired t-Test Results
Maximal mouth opening before surgery	25	45.93	6.34	37.00	59.00	22.00	45.00	z= 0.92 p =0.328
Maximal mouth opening after surgery	25	44.93	8.13	38.00	70.00	32.00	43.00	
Protrusive mouth before surgery	25	2.71	1.14	1.00	5.00	4.00	3.00	t= 0.82 p =0.326
Protrusive mouth after surgery	25	2.50	0.94	1.00	4.00	3.00	2.50	
Left lateral movement of the mouth before surgery	25	8.71	1.07	7.00	11.00	4.00	8.50	z=0.00 p =1.00
Left lateral movement of the mouth after surgery	25	8.71	1.20	7.00	11.00	4.00	8.00	
Right lateral movement of the mouth before surgery	25	9.00	1.04	7.00	11.00	4.00	9.00	t= 0.81 p =0.435
Right lateral movement of the mouth after surgery	25	8.86	1.10	7.00	11.00	4.00	9.00	

€ letter z as a result of Wilcoxon test

Figure 7: Mean, standard deviation, minimum, maximum, range of variation, median, joint angles before and after surgery and the results of statistical tests

Discussion

Mandibular excess (prognathism) is an abnormality based on which abnormal occlusion occur in the incisors as class III malocclusion, molar and canine and reverse overjet due to mandibular growth. Orthognathic surgery is one of the best methods to correct these dental-facial anomalies. In recent decades, orthognathic surgery has been expanded and has become more popular. This surgical treatment involves several phases based on which maxillary and mandibular positions and dentoalveolar units can be changed. However, Orthodontics alone cannot create enough beauty and function. In spite of the benefits of this kind of surgery for occlusion, beauty and function, it is more effective in the position of the lower jaw and condyle than the temporal bone and articular disc position.[2]

The bilateral sagittal split osteotomy is an indispensable tool in the correction of dentofacial abnormalities. Many studies have been conducted on the impact of the surgery on the position of condyle in glenoid cavity and TMD.[1,5,7,10-14] This study was carried out on 25 patients with Class III malocclusion (10 men and 15 women with an average age of 23.2 ± 2.7 years) to evaluate changes in condyle in

coronal, sagittal and axial planes as well as changes in joint space using CBCT and clinical examinations. In this study, the time period was before surgery and six months later. Cone beam computed tomography is (CBCT) is a very accurate radiographic method which uses less radiation than the CT.[15,17] It investigates the condyle at all angles compared to the lateral cephalometric x-ray.[16] In the first six months after surgery, most changes occur in the condyle and then the condyle returns to its position.[18] According to the findings, the axial angle of the left and right condyle was reduced in patients before and after surgery, but this change was not statistically significant. Thus, the condyle was slightly turned inward. This result is consistent with the findings of the study conducted by Kim and Choi.[15,16]

In a study, Kim investigated patients before surgery and six months later using CBCT. He argued that the condyle is slightly turned inward and during the 12 month follow-up, the condyle with external rotation returns to its previous position and this change is not statistically significant. According to the findings, the condylar coronal angle increased on both sides after surgery, but this increase was not statistically significant. This result is consistent with the findings of the study conducted by Kim and Choi. According to a study conducted by Kim, the coronal angle slightly increased in the first 6 months and the angle was significantly reduced after 12 months, and the condyle was rotated toward the midline.[15,16] Considering the distance between the two condyles before and after surgery, it slightly increased after 6 months, but it was not statistically significant. In a study, Kim argued that the distance between the two condyles slightly decreased after three months, but they returned to its previous position after 6 months.[17]

Sagittal condyle angle on the right slightly increased and sagittal condylar angle on the left was slightly reduced, but this change was not statistically significant. This may be due to differences in the performance of surgeons. According to a study conducted by Kim and Ghang, sagittal condylar angle was reduced.[17,16,19] The difference between the left and right condyle could be due to the measurement method. The angle was between the CO (the uppermost point of the condyle) and L (the most posterior point of the upper surface of the condyle) and the Po'-AM (the lowermost point of the condyle). In these studies, the angle between the longitudinal axis of the condyle and FH plane was considered as the sagittal angle. Thus, the difference may be related to the measurement method. In the present study, the condylar inclination, as the angle between the connection of the anterior and posterior point of the glenoid fossa and the longitudinal axis of the condyle, was used. This angle confirms the results of previous studies about a decrease in the sagittal angle. In a study by Hu *et al*., the changes in the sagittal condyle angle were not statistically significant. They used 28 class III malocclusion patients who underwent BSSO and Lefort I. In order to investigate the changes in condyle based on Torenes and Sund, the lateral cephalometric radiograph was used with the opened and closed mouth before surgery and six months later.[20] The anterior joint space decreased, indicating the joint movement toward the front of the body. This decrease in the joint space on the left was not significant and this could be due to difference in surgical performance on the left and right. The results of other studies showed the condyle moved forward in the joint space. The findings of a study conducted by Kim during12 months showed that the condyle position becomes more anterior in 6 months after surgery, and then returns to its previous position. This can be due to edema or hemarthrosis.

Chen conducted a study on class II patients and concluded that the condyle moves forward in 43% of patients. In this research, Kamelchuk was used to measure the joint space and Pullinger – Hollender was used to measure the anterior and posterior condylar positions.[14] According to Kamelchuk method for measuring the anterior, posterior and the upper joint space, a line of the uppermost point of glenoid fossa parallel to FH plane is drawn. From this point, a tangent line to the most prominent point of the condyle is drawn on the anterior and posterior side. Thus, the vertical distance between the lines and the glenoid fossa is considered as the posterior and anterior space. The upper joint space includes the distance between the uppermost point of the condyle and the uppermost point of the glenoid fossa. In clinical examinations, maximal mouth opening, and lateral and protrusive mandibular movements were reduced, but this reduction was not statistically significant. In addition, 19 patients (76%) (12 women and 7 men) had the symptoms of TMD, including clicking, disc dislocation with reduction and morphologic changes in the preoperative radiograph. Nine patients (5 women and 4 men) had previous symptoms after surgery. No pain or crepitus was mentioned. Examining temporomandibular joints is important before surgery. Moore *et al*. stated 5 analyses of the condyle in patients undergoing orthognathic surgery and the results showed that three of them have preoperative symptoms of dysfunction before surgery.[21] Arent and Tomborello stated 10 analyses of the condyle after orthognathic surgery and concluded that all of the patients have preoperative symptoms of dysfunction before surgery and six patients have preoperative symptoms of dysfunction after surgery.[22] The results of the study showed that Bilateral Sagittal Split Osteotomy (BSSO) for skeletal Class III patients did not have a significant effect on the position of the condyle in the glenoid cavity and symptoms of TMD. The results of studies on changes in the condylar position after orthognathic surgery confirm the results of the present study.[23,24] Changes in the condylar after orthognathic surgery can be due to posture in the patient, the stretched masticatory muscles, the type of fracture, the way of fixation and the previous position of the condyle.[17]

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