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BASIC RESEARCH:

Evaluating Mandibular Condyle Position Changes After Orthognathic Surgery: A Systematic Review and Meta-Analysis

Evaluación de los cambios en la posición del cóndilo mandibular después de cirugía ortognática: una revisión sistemática y metaanálisis

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ABSTRACT: Present research aims to evaluate mandibular condyle position changes after bilateral sagittal split osteotomy and bimaxillary orthognathic surgery. Relevant keywords were searched in the international databases Cochrane, Embase, and MEDLINE (PubMed and Ovid) up to January 2025. The Newcastle-Ottawa Scale used to determine the quality of the studies. Mean change of condylar values was used as an effect size with random-effects model and REML methods of 95% confidence intervals (CI). Meta-analysis performed using Stata (as of version 17). The mean change of left condylar position pre- and postoperative values of BSSO was -0.28º (ES -0.28º 95% CI; -1.59º, 1.03º; $p<0.05$). Non-significant mean values of condylar position pre- and postoperative of BSSO and bimaxillary orthognathic surgery in left sagittal plane was observed ($p>0.05$). The mandibular condyle position after surgery is influenced to some extent by orthognathic surgery.

KEYWORDS: Orthognathic surgery; Mandibular condyle; Orthognathic surgical procedures.

RESUMEN: La presente investigación tiene como objetivo evaluar los cambios en la posición del cóndilo mandibular tras la osteotomía sagital bilateral (BSSO) y la cirugía ortognática bimaxilar. Se realizó una búsqueda de palabras clave relevantes en las bases de datos internacionales Cochrane, Embase y MEDLINE (PubMed y Ovid) hasta enero de 2025. La calidad de los estudios se determinó mediante la escala Newcastle-Ottawa. El cambio promedio de los valores condilares se utilizó como medida de efecto, aplicando un modelo de efectos aleatorios y métodos REML con intervalos de confianza (IC) del 95%. El metaanálisis se llevó a cabo utilizando Stata (versión 17). El cambio promedio en la posición

condilar izquierda entre los valores pre y postoperatorios de BSSO fue de -0.28º (ES -0.28º; IC 95%: -1.59º, 1.03º; p<0.05). Se observaron valores promedio no significativos en la posición condilar pre y postoperatoria de BSSO y de cirugía ortognática bimaxilar en el plano sagital izquierdo (p>0.05). Los hallazgos sugieren que la posición del cóndilo mandibular después de la cirugía se ve influida, en cierta medida, por la intervención ortognática.

PALABRAS CLAVE: Cirugía ortognática; Cóndilo mandibular; Procedimientos quirúrgicos ortognáticos.

INTRODUCTION

Correct maxillofacial occlusal inconsistencies and abnormalities can be corrected with different orthognathic surgery methods (1). Mandibular and/or maxillary osteotomy are orthognathic surgery methods (2). Airway obstruction, facial harmony, and temporomandibular joint (TMJ) function should be carefully evaluated in preoperative planning (3). One of the most commonly used techniques, introduced by Obwegeser and Trauner, is bilateral sagittal split osteotomy (BSSO) (4). In BSSO, the lower jaw is separated from the face and placed in position (5). The medical technique for internally set and stabilization of broken bones is internal fixation (IF), which generally uses bicortical or monocortical screws and miniplates (6). TMJ function, long-term skeletal stability, and favorable postoperative outcomes all depend on proper condylar seating. Malocclusion can result from central or peripheral condylar sagging, either during the recovery process after the perioperative maxillomandibular fixation (MMF) is removed. In addition, condylar resorption and skeletal relapse may occur (6).

The condyle must not be rotated or displaced during mandibular osteosynthesis (7). With proper surgical technique, condylar remodeling should be minimal. There is an ongoing debate about the choice between semi-rigid internal fixation and rigid internal fixation (RIF). To facilitate postoperative skeletal stability, segmental displacement must be avoided by removing all bony interference and leaving the necessary gaps between segments (8). Condylar position and postoperative TMJ function can be influenced by all mandibular osteosynthesis techniques used in orthognathic surgery. Temporomandibular joint dysfunction can result from incorrect postoperative condylar position, future condylar resorption, and disc displacement (9-11). Due to the importance of the issue, present research aims to evaluate mandibular condyle position changes after BSSO and bimaxillary orthognathic surgery.

METHOD

SEARCH STRATEGY AND INFORMATION SOURCES

To determine the purpose of the study, relevant keywords were searched in the international databases Cochrane, Embase, and MEDLINE (PubMed and Ovid) up to January 2025. Google Scholar, CENTRAL (Cochrane Central Register of Controlled Trials), WOS (Web of Science), EBSCO,

ISI, Elsevier, and the Scopus Wiley Online Library were also consulted. The current study is based on the 27-point checklist PRISMA 2020 (12).

The search strategy used in MEDLINE (via PubMed):

(((((((("Orthognathic Surgery" [Mesh] OR "Orthognathic Surgical Procedures" [Mesh]) OR "Orthognathic Surgery/methods" [Mesh]) OR "Surgery, Oral" [Mesh]) AND "Mandibular Condyle" [Mesh]) OR ("Mandibular Condyle/diagnostic imaging" [Mesh] OR "Mandibular Condyle/injuries" [Mesh] OR "Mandibular Condyle/surgery" [Mesh])) AND "Mandible" [Mesh]) AND "Jaw" [Mesh]) AND "Postoperative Period" [Mesh]) AND "Preoperative Period" [Mesh].

The search strategy used in Cochrane:

"Orthognathic Surgery" OR "bilateral sagittal split osteotomy" OR "bimaxillary surgery" AND "Condylar position" OR "mandibular condyle" OR "condylar position changes" AND "Preoperative" AND "postoperative" AND "axial planes" OR "sagittal planes".

The search strategy used in Embase:

(Orthognathic Surgery) OR (bilateral sagittal split osteotomy) OR (bimaxillary surgery): ab,ti,kw

Mandibular condyle: ab,ti,kw

(Condylar position) OR (condylar position changes): ab,ti,kw

SELECTION CRITERIA

Only studies published in English were considered. The PICO strategy was used to answer the questions in the present study. Population (P): Patients undergoing BSSO and bimaxillary; Intervention (I): BSSO or bimaxillary; comparison (C): pre- and postoperative; Outcome (O): condylar position changes. studies have been conducted in a review, laboratory and animal form; books; qualitative studies; Studies with incomplete data and case report studies were excluded from the study.

THE PROCESS OF SELECTION AND DATA COLLECTION

Two blind and independent researchers reviewed the data of the selected studies and the third researcher summarized. The data was collected using a pre-designed form by the research team that includes sections such as the name of the first author of the study, year of publication, study design, number of patients, gender, mean age, malocclusion type, orthognathic surgery and radiographic evaluation.

STATISTICAL HETEROGENEITY

Chi-square test ($\chi 2$) and I2 to determine heterogeneity between studies. The value of I2 checked in four levels (low heterogeneity: ≤25%; moderate: 25%-50%; substantial: 50%-75%; considerable: ≥ 75%.

METHODOLOGICAL QUALITY

The Newcastle-Ottawa Scale (NOS) was used to determine the quality of the studies. This scale examines the risk of bias in three areas: study group selection, group comparability, and outcome determination. For each study, a total score was created by adding up the ratings assigned to each criterion. Based on NOS scores, studies were classified into low (7-9), medium (4-6), or high (0-3) risk of bias studies.

DATA ANALYSIS

Mean change of condylar values was used as an effect size with random-effects model and REML methods of 95% confidence intervals (CI).

Meta-analysis performed using Stata (as of version 17). Statistical significance was considered less than 0.05.

RESULTS

DESCRIPTION OF STUDIES

A total of 219 articles were found in international databases during the initial search using related keywords. Two blind, independent researchers reviewed the articles and eliminated any articles that were duplicate or unrelated to the study topic. Abstracts of 143 studies were reviewed based on the inclusion criteria (109 articles were removed at this stage); the full texts of 34 articles were examined; only nine of these articles were included in the study because they were consistent with the objectives (Figure 1).

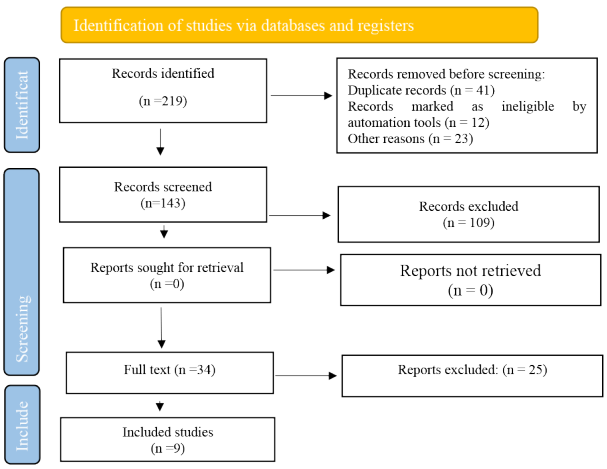

Figure 1. PRISMA 2020 Checklist.

STUDY CHARACTERISTICS

A total of 324 patients (192 female and 11 male; One study did not report the gender of the participants (13)) with 25.30 mean age were included. Malocclusion III, II and I were reported in 194, 50 and 5 patients, respectively; Two studies did not report the type of malocclusion (14, 15). BSSO was performed in 154 patients (11, 13, 14, 16). Bimaxillary surgery was performed in 170 patients(11, 17) (15, 18-20). Five (11, 13, 14, 16, 19) and four studies (15, 17, 18, 20) examined CT scan and CBCT before and after surgery, respectively (Table 1).

BIAS ASSESSMENTS

As shown in Table 2, one study was rated as "fair" by NOS (13), and eight studies were of high quality.

AXIAL PLANE

The mean change of left condylar position pre- and postoperative values of BSSO was -0.28º (ES -0.28º 95% CI; -1.59º, 1.03º; $p<0.05$), a significant inward rotation of the left condyle after BSSO. I2 statistic was 0% ($p=0.99$) that showed low heterogeneity (Figure 2).

The mean change of left condylar position pre- and postoperative values of bimaxillary orthognathic surgery was –0.30º (ES -0.30º 95% CI; -1.35º, 0.76º; $p<0.05$), a significant inward rotation of the left condyle after bimaxillary orthognathic surgery. I2 statistic was 0% ($p=1.00$) that showed low heterogeneity (Figure 2).

According to test of group differences, left condylar position changes was similar between the bimaxillary and BSSO ($p=0.99$) (Figure 2).

No significant change was observed between mean change of right condylar position pre- and postoperative values of BSSO (ES 1.03º 95% CI;

-0.36º, 2.43º; p>0.05) and bimaxillary orthognathic surgery (ES 0.28º 95% CI; -0.77º, 1.34º; p>0.05) (Figure 3). According to test of group differences, right condylar position changes were almost the same in both groups (p=40) (Figure 3).

The mean difference of left and right condylar position pre- and postoperative values of BSSO and bimaxillary orthognathic surgery was not statistically significant (p>0.05); No significant difference was observed between the groups (p=0.51, p=0.14) (Figure 4 and Figure 5).

CORONAL PLANE

Non-significant mean values of condylar position pre- and postoperative of BSSO and bimaxillary orthognathic surgery in left sagittal plane was observed (p>0.05) (Figure 6).

Right condyle rotated outward postoperatively after BSSO (ES 0.23º 95% CI; -1.08º, 1.54º; p<0.05) and bimaxillary orthognathic surgery (ES 0.13º 95% CI; -1.01º, 1.27º; p<0.05). two groups were similar (p=0.91) (Figure 7).

Table 1. Characteristics of included studies.

Study Years	Study design	Number of patients	Gender		Mean age	Malocclusion type (n)	Orthognathic surgery	Radiographic evaluation
			Female	Male				
Dvoranova *et al.*, 2024 (11)	ReS	99	79	20	27.5	III malocclusion (57) II malocclusion	BSSO (51) BOS (48	CT scans
Buch *et al.*, 2024 (17)	ReS	16	5	11	27	III malocclusion (7) II malocclusion (4) I malocclusion (5)	BOS	CBCT
Küçükçakır *et al.*, 2024 (18)	ReS	44	20	24	22.6	III malocclusion (44)	BOS	CBCT
Kaur *et al.*, 2022 (14)	PoS	37	18	19	22	NR	BSSO	CT scans
Lee *et al.*, 2022 (19)	PoS	11	7	4	21.1	III malocclusion	BOS	CT scans
Park *et al.*, 2022 (20)	ReS	23	14	9	22.5	III malocclusion	BOS	CBCT
Shrestha *et al.*, 2021 (13)	ReS	21	NR	NR	24	III malocclusion	BSSO	CT scans
Hirjak *et al.*, 2020 (16)	ReS	45	34	11	30	III malocclusion (31) II malocclusion (14)	BSSO	CT scans
Claus *et al.*, 2019 (15)	ReS	28	15	13	31.07	NR	BOS	CBCT

ReS: retrospective study; PoS: prospective study; BSSO: bilateral sagittal split osteotomy; BOS: Bimaxillary orthognathic surgery; NR: not reported.

Table 2. Bias assessments of included studies according to NOS scale.

Study. Years	Selection			Comparability		Outcomes			Score
	A	B	C	D	E	F	G	H	
Dvoranova *et al.*, 2024 (11)	★	★	★	★	☆★	★	★	★	8
Buch *et al.*, 2024 (17)	★	★	★	★	☆★	★	★	★	8
Küçükçakır *et al.*, 2024 (18)	★	★	★	★	☆☆	★	★	★	7
Kaur *et al.*, 2022 (14)	★	★	★	★	☆★	★	★	★	8
Lee *et al.*, 2022 (19)	★	★	★	★	☆★	★	★	★	8
Park *et al.*, 2022 (20)	★	★	★	★	☆★	★	★	★	8
Shrestha *et al.*, 2021 (13)	★	☆	☆	★	☆★	★	★	★	6
Hirjak *et al.*, 2020 (16)	★	★	★	★	☆★	★	★	★	8
Claus *et al.*,2019 (15)	★	★	★	★	☆★	★	☆	★	7

A: Representativeness of the Exposed Cohort; B: Selection of the Non-Exposed Cohort; C: Ascertainment of Exposure; D: Demonstration That Outcome of Interest Was Not Present at Start of Study; E: Demonstration That Outcome of Interest Was Not Present at Start of Study; F: Assessment of Outcome; G: Follow-Up Long; H: Adequacy of Follow-Up of Cohorts.
Black stars (★) to signify that a study satisfactorily meets a specific criterion. White stars (☆) indicate that a criterion is not met.

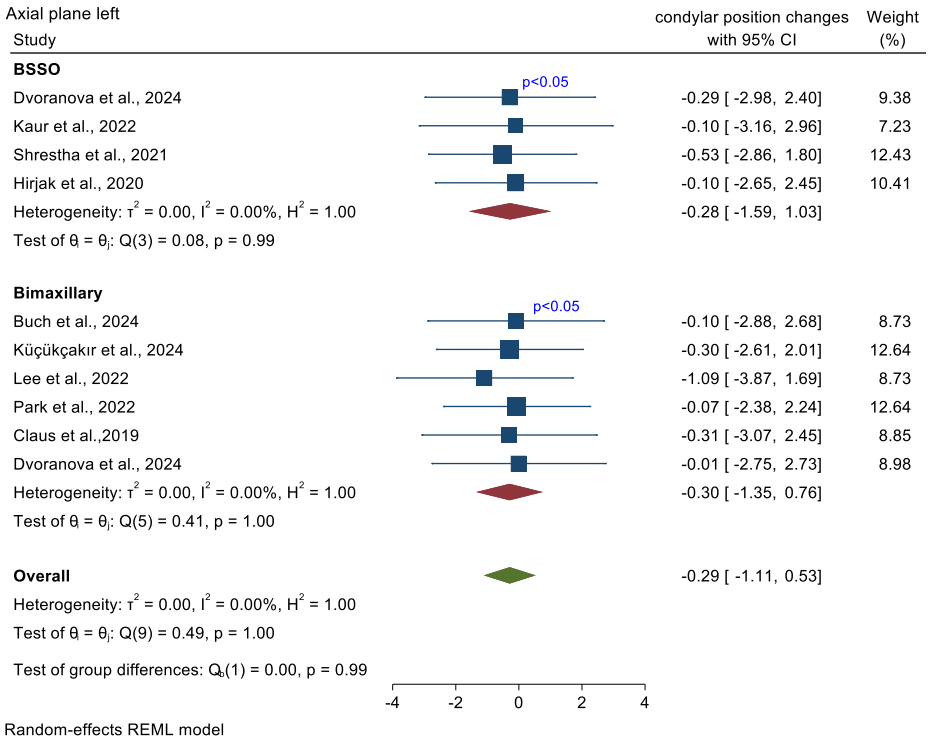

Figure 2. Forest plot showed mean change of left condylar position in axial plane pre- and postoperative values after orthognathic surgery.

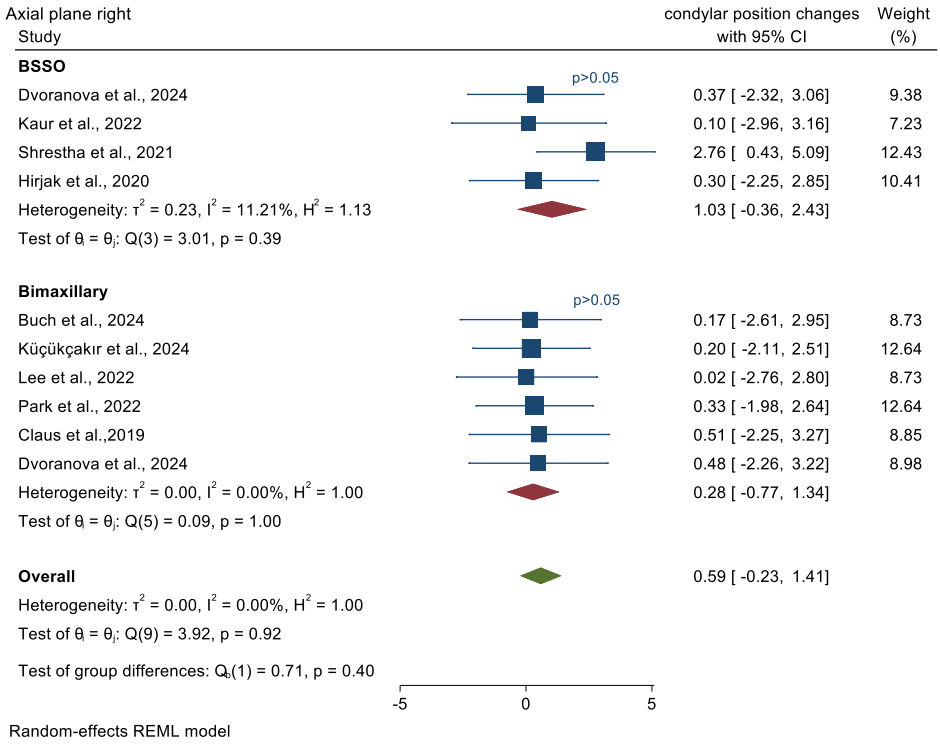

Figure 3. Forest plot showed mean change of right condylar position in axial plane pre- and postoperative values after orthognathic surgery.

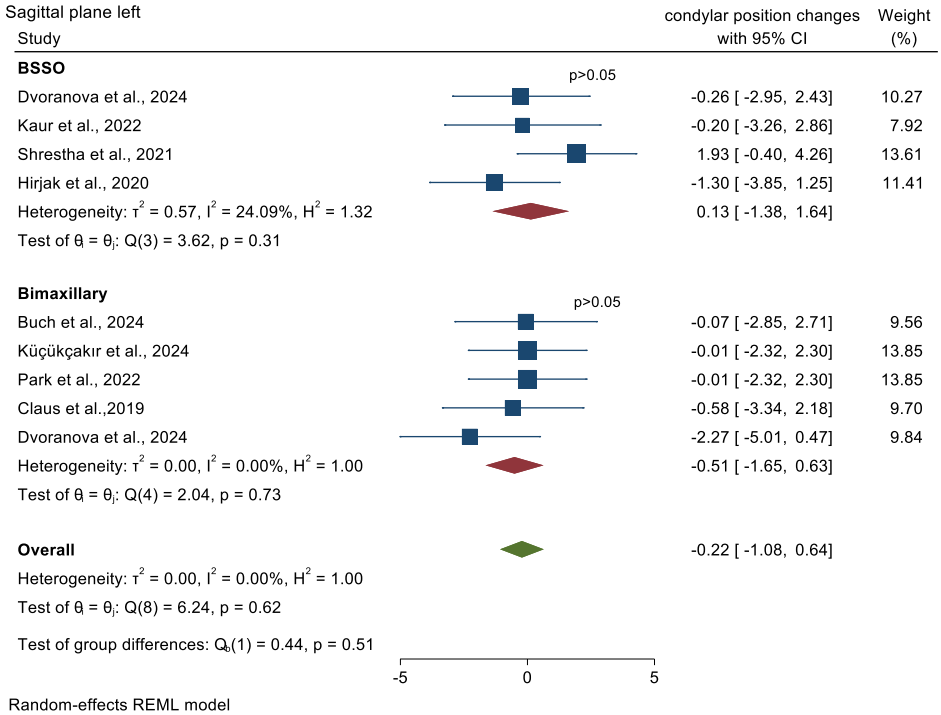

Figure 4. Forest plot showed mean change of left condylar position in sagittal plane pre- and postoperative values after orthognathic surgery.

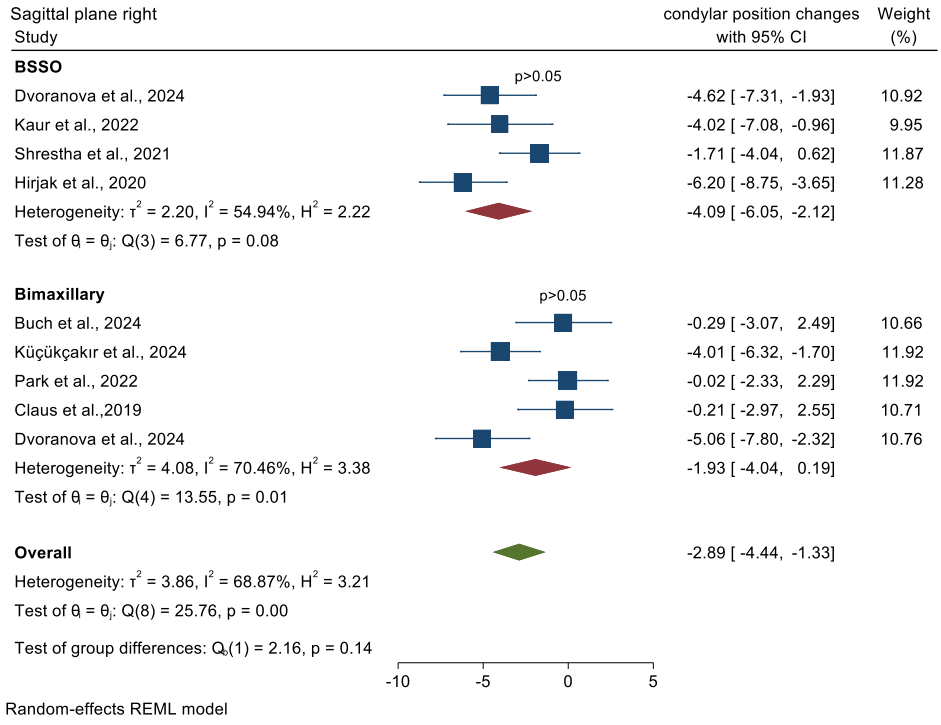

Figure 5. Forest plot showed mean change of right condylar position in sagittal plane pre- and postoperative values after orthognathic surgery.

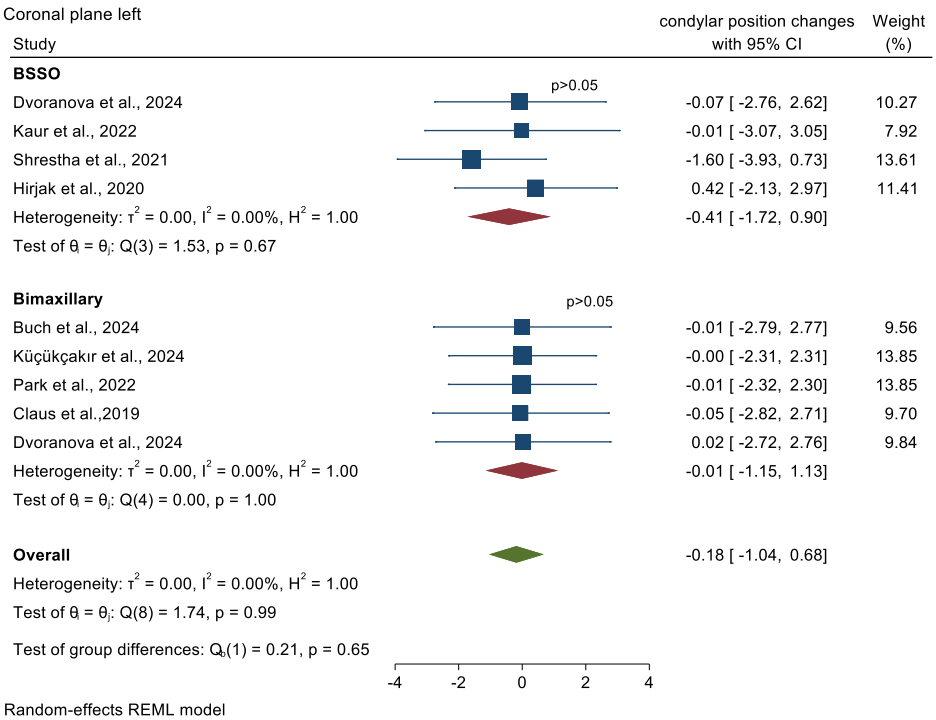

Figure 6. forest plot showed mean change of left condylar position in coronal plane pre- and postoperative values of orthognathic surgery.

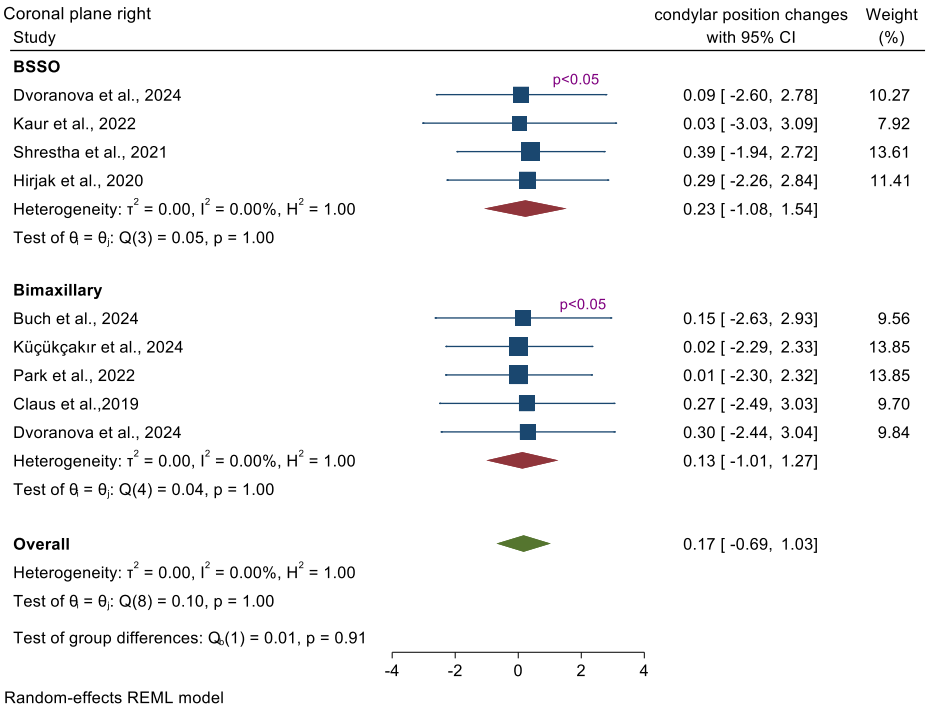

Figure 7. forest plot showed mean change of right condylar position in coronal plane pre- and postoperative values of orthognathic surgery.

DISCUSSION

Condylar resorption, malocclusion, skeletal relapse, and TMJ dysfunction can all result from changes in condylar position after orthognathic surgery (21). Peripheral and central are the two main categories that Reyneke and Ferretti (2002) divided the various forms of condylar displacement and condylar sagging (22). Other factors affecting condylar position include the extent of segment movement, local anatomy, the presence of possible bony interference, and the experience of the surgeon performing the procedure. The degree of mandibular rotation, the extent of distal segment movement, and local anatomy all suggested that the shape of the mandible may be important, according to Harris *et al*. (1992)(23).

Following orthognathic surgery, condylar position may also be significantly influenced by the type of osteosynthesis (7). Notwithstanding the documented risk of condylar displacement and increased rates of skeletal relapse, some studies continue to advocate for bicortical screws (24). One miniplate with monocortical screws is preferred by some studies, while two miniplates are used by others studies (8, 25). Using bicortical screws to fix BSSO did not significantly alter condylar position or function, according to studies (26, 27). Studies reported once orthognathic surgery is completed, mild condylar remodeling is typical(28-30).

In the present study, observed that significant changes in pre-and postoperative values in left and right condyle in the axial plane, also right condyle rotated outward postoperatively in the coronal plane. Jung *et al*. (2017), who evaluated CT images with a condylar positioning plate, found that the angle of the left condylar axis was significantly different, while there were no noticeable differences on the right side(31). Choi *et al*. (2018) observed an increase in α-angle after surgery, which returned to preoperative levels six months later(32). Kim *et al*. (2010), revealed that the angle

of the mandibular condyle increased by 2.23° on the right side and 2.18° on the left side, resulting in internal rotation (33).

A meta-analysis study was not found that could compare the results, however, in a review study it was shown that increased risk of Condylar resorption after orthognathic surgery was associated with mandibular advancement superior than 10 mm, reverse condylar repositioning, and counterclockwise rotation of the mandible (21). Barretto *et al.*, 2022 in a systematic review evaluate methods of mandibular condyle position and rotation center used for orthognathic surgery planning and showed axis of rotation for orthognathic surgery planning must be fixed, permit individualization for each condyle and be reproducible.

CONCLUSION

According to the present meta-analysis, the mandibular condyle position after surgery is influenced to some extent by orthognathic surgery; more care should be taken when rotating the condyle in the transverse axis. Due to the small number of selected study samples and the difference in evaluation methods, more studies are needed in terms of similar investigated parameters, long follow-up period, and higher sample size.

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