

Article

Health and TMJ Function in Adult Patients Treated for Dentoskeletal Open Bite with Orthognathic Surgery—A Retrospective Cohort Study

Mariachiara Benetti ¹ , Luca Montresor ¹ , Lorenzo Trevisiol ^{2,3} , Antonio D'Agostino ⁴, Nicoletta Zerman ^{5,6}, Alessio Verdecchia ^{1,*}  and Enrico Spinass ^{1,*} 

- ¹ Department of Surgical Sciences, Postgraduate School in Orthodontics, University of Cagliari, 09124 Cagliari, Italy; mariachiara.benetti@gmail.com (M.B.); luca.montresor.vr@gmail.com (L.M.)
 - ² Centre for Medical Sciences (CISMed), University of Trento, 38122 Trento, Italy; lorenzo.trevisiol@unitn.it
 - ³ Unit of Maxillo-Facial Surgery, Santa Chiara Regional Hospital, APSS, 38122 Trento, Italy
 - ⁴ Section of Oral and Maxillofacial Surgery, Department of Surgical Sciences, Dentistry, Gynecology and Pediatrics, University of Verona, 37124 Verona, Italy; antonio.dagostino@univr.it
 - ⁵ Department of Surgical Science, Dentistry, Pediatrics and Gynecology, University of Verona, 37134 Verona, Italy; nicoletta.zerman@univr.it
 - ⁶ Pediatric Dentistry and Oral Hygiene Unit, IRCCS Sacro Cuore-Don Calabria Hospital, 37024 Negrar di Valpolicella, Italy
- * Correspondence: verdecchia.belli.a@gmail.com (A.V.); enricospinas@tiscali.it (E.S.)

Abstract: This study aims to assess the presence and progression of TMD in adult patients undergoing orthognathic surgery to correct dentoskeletal open bite and evaluate whether these changes can be attributed to the intervention. A retrospective cohort study was conducted on 44 adult patients (14 males and 30 females) aged 18 to 43 years. Articular assessments were performed to evaluate temporomandibular joint (TMJ) health and functionality before (T0) and after (T1) combined orthodontic-surgical treatment. TMJ health was assessed by maximum mouth opening, joint noises, parafunctions (bruxism or clenching), joint locking, TMJ pain, masticatory muscle pain, and headaches. Statistical analyses used McNemar's Exact Test and paired T-tests. The study shows a significant reduction ($p < 0.05$) in symptoms, except for locking, with the most substantial decrease in headaches ($p = 0.0001$). Overall, articular symptoms markedly decreased post-surgery, with sustained joint functionality. Restoring physiological occlusion in patients with anterior open bite is crucial for maintaining the stomatognathic system's balance. Orthognathic surgery, when indicated, appears beneficial in alleviating articular symptoms while preserving TMJ function.

Keywords: TMJ; TMJD; open bite; orthognathic surgery; retrospective study



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1. Introduction

The temporomandibular joint (TMJ) is a double condyloid joint, characterized by a biconcave fibrocartilaginous disc interposed between the mandibular condyle and the glenoid fossa of the temporal bone, creating two distinct cavities that function as two joints in series [1]. Due to the anatomical complexity of this structure and the wide range of movements it can perform, temporomandibular disorders (TMD) are quite common.

It is estimated that TMD affects 5–12% of the general population, with a higher prevalence in women than in men [2]. The etiology of TMD is complex and multifactorial, involving biomechanical, neuromuscular, biopsychosocial, and biological factors [3].

The American Academy of Orofacial Pain (AAOP) defines temporomandibular dysfunction (TMD) as a set of clinical signs affecting the masticatory muscles, the temporomandibular joint (TMJ), and associated structures [4]. The primary clinical signs of TMD include joint noises, limitations or deviations in mandibular movements during opening,

closing, protrusion, and lateral movements, tenderness or pain in the TMJ upon palpation, and otologic symptoms such as tinnitus and dizziness.

Non-invasive treatments are effective in managing TMD, with new promising options emerging. Surgery is reserved for severe cases and is ideally combined with conservative therapies [5]. The correlation between malocclusions and TMD has long been debated in the literature, with no consensus on the role of occlusal factors in TMD. Some authors [6] argue that malocclusions are rarely associated with signs of TMD. Among the various malocclusions cited, a bilateral open bite greater than 3 mm appears to be associated with TMD signs. As the degree of occlusal and skeletal discrepancy increases, the likelihood of developing joint disorders also increases. Other authors [7] contend that individuals possess varying degrees of physiological adaptability to disharmonies or interferences, with this adaptability limit differing from person to person. Therefore, it can be stated that malocclusion in itself does not necessarily contribute to the onset of TMJ disorders [8,9]. Anterior open bite is a severe malocclusion characterized by the absence of overbite when the teeth are in maximum intercuspation [10–13]. A correct overbite, ranging between 2 and 4 mm, is essential to ensure proper occlusion and is a key objective in dental treatments. The problems associated with anterior open bite are numerous and often proportional to the severity of the condition, necessitating correction. The literature presents various treatment options [14,15], including non-surgical and combined orthodontic-surgical approaches.

In adult patients with completed growth and significant vertical skeletal discrepancy, therapeutic options are greatly reduced, with orthognathic surgery often being the only effective method to correct the defect and maintain stable results over time [16,17]. Although orthognathic surgery is widely used to correct various dentofacial deformities, there is a gap in the literature regarding its impact on TMJ dysfunction [18].

Therefore, the objectives of this research are: (1) to evaluate the progression of the health and functionality of the temporomandibular joint (TMJ) in adult patients treated with pre-surgical orthodontics and orthognathic surgery for skeletal anterior open bite, and (2) to assess whether the treatment and the resolution of the malocclusion can influence the health status of the TMJ.

2. Materials and Methods

This study was conducted between 2005 and 2012 at the Department of Dentistry and Maxillofacial Surgery of the “G.B. Rossi” Hospital in Verona. The Institutional Review Board (IRB) of the University of Verona granted an exemption from ethical committee approval for the portion of the sample previously examined in earlier studies [16,17]. A total of 229 patient underwent orthognathic surgery during those 7 years. The inclusion criteria were patients with of a dento-skeletal anterior open bite that required correction with combined orthodontic-surgical therapy, skeletal growth completed, an accentuated Curve of Spee, and a multisegment maxilla intervention. Patients with deep carious lesions, jaw injuries, arthritis, connective tissue diseases, and reduced anterior vertical dimension were excluded from the sample. To minimize potential confounding factors, only patients operated on by the same team (L.T. and A.D.) and following the same therapeutic protocol were included in the study. The selected sample consists of 44 adult patients, 28 females and 16 males, with an average age of 24 years (ranging from 18 to 43 years), all affected by dento-skeletal anterior open bite. All patients received combined orthodontic-surgical therapy for maxillomandibular deformities. The assessment was conducted using a specific joint test developed according to AAOP guidelines [4] to evaluate the progression of the main clinical signs associated with TMD. The parameters examined in the test were:

- a. Maximum mouth opening (OPEN): Expressed in mm, measured clinically by the distance between the incisal edges of the upper and lower central incisors.
- b. Presence of joint noises (CLICK): Unilateral or bilateral, such as clicks or pops, determined by palpation and auscultation of the TMJ during opening, closing, lateral, and protrusive movements.

- c. Presence of parafunctions such as bruxism or clenching (GRIND), evaluated by assessing muscle tone and asking the patient about these habits during both night and day.
- d. Episodes of joint locking (LOCK): Patients were asked to report any episodes of joint locking.
- e. TMJ pain (ATM PAIN): assessed clinically by palpation of the joint, with patients reporting any spontaneous pain.
- f. Muscle pain in the masticatory muscles (MUSC PAIN): Investigated through palpation of the muscles and patient reports of any spontaneous pain.
- g. Presence of headaches (HA): Patients were asked if they suffered from headaches and to report the frequency and intensity of the condition.

For each of the variables considered, the presence or absence of the symptom, as well as any decrease in the frequency and/or intensity of the symptom during the follow-up evaluation, was assessed. The tests were conducted before (T0) and after (T1) the combined orthodontic-surgical treatment. T0 indicates the presence or absence of symptoms before starting the ortho-surgical treatment, T1 represents the same tests after the treatment. No long-term evaluation was reported.

At the initial visit, documentation was collected, including plaster study models, orthopantomographs of the dental arches, lateral cephalometric radiographs, and intraoral and extraoral photographs. Cephalometric analyses were then performed using Dolphin Software (Version 11.8), plaster models were mounted on an articulator, and the joint test was conducted at time 0. Once the orthodontic-surgical treatment plan was established, a CT scan of the facial complex was performed, the surgical simulation was carried out, and the orthodontic planning was finalized.

The first phase of treatment involved pre-surgical orthodontics for approximately 18–24 months. All patients underwent orthognathic surgery, specifically, a Le Fort I osteotomy on the maxilla (either single-piece or tripartite), and a bilateral sagittal split osteotomy on the mandibular arch. In the immediate postoperative period, patients wore inter-arch elastics for intermaxillary stabilization. The final phase of treatment included post-surgical orthodontics lasting about 6 months to stabilize and finish the case.

To minimize potential biases, all joint tests were performed twice by two different operators (M.B. and L.M.) who were trained for 5 months by the surgeons (L.T. and A.D.) who later performed the surgery. The aim of the joint test was to assess the potential correlation between dento-skeletal open bite and the presence of temporomandibular disorders (TMD) as well as to observe changes in TMD symptoms following the corrective orthodontic-surgical intervention.

Statistical analyses were performed with Stata 18 software, employing two types of tests: the McNemar Exact test for all dichotomous variables, and the paired T-test) for evaluating the means of mouth opening at T0 and T1.

3. Results

3.1. Results of the Joint Test

The results obtained from the joint test are summarized in Tables 1 and 2.

Table 1. Open test results.

Symptom	Open T0	Open T1	T-Value	p-Value
Open	51.46 ± 5.20 mm	46.82 ± 5.11 mm	4.5107	0.0001

Table 2. Joint test results.

Symptom	Occurrence T0	Occurrence T1	Reduction T1	<i>p</i> -Value
Click	23	12	4	0.0192
Gring	16	8	2	0.0386
Lock	3	3	-	1.0000
ATM Pain	12	3	-	0.0117
Musc Pain	14	3	1	0.0074
HA	20	2	4	0.0001

3.1.1. Maximum Mouth Opening (Open)

The average maximum opening before surgery (T0) was 51.46 ± 5.20 mm. After surgery (T1), the average opening decreased to 46.82 ± 5.11 mm.

3.1.2. Presence of Joint Noises (Click)

Unilateral or bilateral joint noises were present in 23 out of 44 patients before surgery. After surgery, joint noises were observed in 12 patients, 8 of whom had the condition before surgery, and in the remaining 4 patients, the condition appeared postoperatively. Joint noises resolved in 11 patients and significantly decreased in frequency and intensity in 4 patients. Thus, the number of patients without joint noises after surgery was 28.

3.1.3. Presence of Parafunctions (Grind)

Before the intervention, 16 subjects reported habits of clenching or bruxism. Postoperatively, only 8 subjects reported such habits, with 2 experiencing a significant decrease in episode frequency. Among the 8 postoperative cases subjects, 6 had a history of bruxism or clenching before the surgery, while 2 did not.

3.1.4. Episodes of Joint Locking (Lock)

Before the intervention, 3 patients reported episodes of joint locking. Postoperatively, only 3 patients who had never experienced joint locking before reported a single episode of locking.

3.1.5. ATM Pain

Preoperatively, 12 patients experienced pain upon palpation or spontaneously. Postoperatively, only 3 patients reported pain, with 1 developing it after surgery and 2 having had it preoperatively. Consequently, 9 patients experienced resolution of pain symptoms after the intervention.

3.1.6. Muscle Pain in Masticatory Muscles (Musc Pain)

Before surgery, 14 patients reported muscle pain: 8 primarily in the temporal muscles, 4 mainly in the neck muscles, and the remaining in the masseter muscle. Postoperatively, only 3 patients reported muscle pain, 2 of whom did not have it preoperatively. One patient experienced a significant reduction in pain symptoms.

3.1.7. Presence of Headaches (HA)

Headaches were present in 20 subjects before the intervention. Postoperatively, headaches were reported by only 2 patients, with 4 patients experiencing a decrease in frequency and intensity. No patients without preoperative headache symptoms reported headaches after the intervention.

The complete results of the joint test are reported in Table 3.

Table 3. Overview of joint test results on the selected sample.

Obs	Open T0	Open T1	Click T0	Click T1	ATM Pain T0	ATM Pain T1	Grind T0	Grind T1	Musc Pain T0	Musc Pain T1	HA T0	HA T1	Lock T0	Lock T1
P1	46	43	1	0	1	0	0	0	1	0	1	0	0	0
P2	N/A	40	1	0	0	0	0	0	0	0	0	0	0	0
P3	58	55	1	0	1	0	1	0	1	0	0	0	0	0
P4	43	43	1	0	1	0	1	0	1	0	1	0	0	0
P5	53	52	0	0	0	0	0	0	1	0	0	0	0	0
P6	51	50	0	0	1	0	0	0	1	0	0	0	0	0
P7	55	50	0	0	0	0	1	0	1	0	1	0	1	0
P8	N/A	44	1	1	1	0	0	0	0	0	0	0	0	0
P9	50	47	1	0	1	0	1	1	1	0	1	0	0	0
P10	50	53	1	0	1	0	0	0	1	0	0	0	0	0
P11	52	47	0	1	0	1	0	0	0	1	1	1	0	0
P12	53	52	1	0	0	0	1	1	0	0	0	0	0	0
P13	50	51	1	0	0	0	1	0	0	0	1	0	1	0
P14	45	N/A	0	1	0	0	0	1	0	0	0	0	0	0
P15	N/A	45	1	1	0	0	1	1	1	0	1	0	0	0
P16	58	51	0	0	0	0	0	0	0	0	0	0	0	0
P17	45	47	0	0	0	0	0	0	0	0	0	0	0	0
P18	60	60	1	0	0	0	0	0	0	0	0	0	0	0
P19	44	46	0	0	0	0	0	0	0	0	1	0	0	0
P20	N/A	45	0	0	0	0	0	1	0	0	1	0	0	0
P21	66	52	1	1	0	0	0	0	0	0	0	0	0	0
P22	54	45	1	1	0	0	0	0	0	0	0	0	0	0
P23	51	49	1	0	0	0	1	0	0	0	1	0	0	0
P24	58	N/A	0	0	0	0	1	0	0	0	1	0	0	1
P25	55	46	0	1	0	0	0	0	0	0	0	0	0	0
P26	47	50	1	0	0	0	1	0	0	0	0	0	1	0
P27	48	N/A	0	0	0	0	0	0	0	0	0	0	0	0
P28	52	37	0	0	0	0	0	0	0	0	0	0	0	0
P29	N/A	44	0	0	0	0	1	1	0	0	0	0	0	0
P30	53	40	0	0	0	0	0	0	1	0	1	0	0	0
P31	51	46	1	1	1	1	1	1	1	1	1	1	0	0
P32	53	42	0	1	0	0	0	0	0	0	0	0	0	1
P33	46	45	0	0	0	0	0	0	0	0	0	0	0	0
P34	53	40	1	0	0	0	0	0	0	0	1	0	0	0
P35	48	41	1	0	0	0	0	0	0	0	0	0	0	0
P36	45	47	0	0	0	0	1	1	1	0	1	0	0	0
P37	45	42	0	0	0	0	0	0	0	0	0	0	0	1
P38	47	46	0	0	1	0	0	0	1	0	0	0	0	0
P39	52	49	1	1	0	0	0	0	0	0	0	0	0	0
P40	46	46	1	0	1	1	1	0	0	0	1	0	0	0
P41	57	36	1	0	1	0	1	0	1	0	1	0	0	0
P42	55	54	0	0	1	0	1	0	0	0	1	0	0	0
P43	60	55	1	1	0	0	0	0	0	0	1	0	0	0
P44	52	47	1	1	0	0	0	0	0	1	1	0	0	0

Note: Abbreviations: Obs, observation; P: patient; N/A, not available.

3.2. Results of Statistical Analysis

The results were also analyzed using statistical analysis with Stata 18 software, employing two types of tests: the McNemar Exact test [19] for all dichotomous variables, and the paired T-test [20] for evaluating the means of mouth opening at T0 and T1.

3.2.1. McNemar Test

The McNemar exact test [19] was used to evaluate all variables, except “maximum mouth opening”. This test is typically employed to assess differences in dichotomous data (presence/absence) before and after a treatment, effectively evaluating the treatment’s efficacy. In other words, it determines whether two dependent variables are statistically significantly different from each other. In our case, it assesses whether the combined orthodontic-surgical treatment influenced the outcomes.

For the statistical analysis, cases where the analyzed elements decreased in intensity or frequency were considered as “0”, indicating the disappearance of the symptom. We assumed that any reduction in symptoms indicates a positive trend in our treatment compared to the baseline.

Statistical significance was considered if $p < 0.05$.

The results obtained are as follows:

- Click before and after: Exact McNemar significance probability 0.0192, indicating a significant association.
- TMJ pain before and after: Exact McNemar significance probability 0.0117, indicating a significant association.
- Bruxism or clenching before and after: Exact McNemar significance probability 0.0386, indicating a significant association.
- Masticatory Muscle Pain before and after: Exact McNemar significance probability 0.0074, indicating a significant association.
- Headaches before and after: Exact McNemar significance probability 0.0000, indicating a significant association.
- Locking before and after: Exact McNemar significance probability 1.0000, indicating no significant association.

3.2.2. Paired T-Test

For the variable “Opening before and after”, a test for the difference between two means for dependent samples was used, specifically the paired T-test [21]. This analysis determines whether the mean difference between pairs of measurements is statistically different from zero. As shown in Table 1, the t-value is 4.5107 and the p -value is 0.0001, indicating that the mean opening values before and after treatment differ in a statistically significant manner. The histogram in Figure 1 also clearly demonstrates a distinct change in the variable’s trend before and after treatment. This suggests that our treatment has significantly influenced the outcomes.

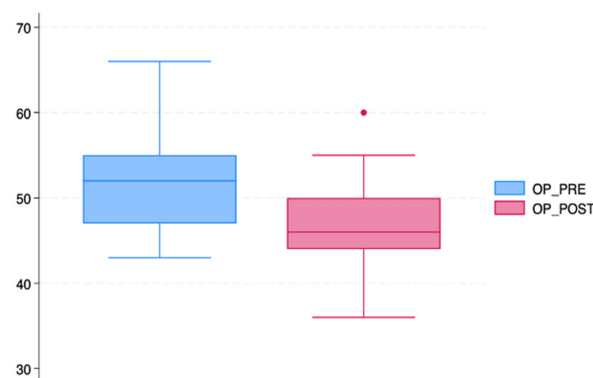


Figure 1. Box plot variables Open T0 and T1. Note: Abbreviations: OP_PRE, open T0; OP_POST, open T1.

4. Discussion

The impact of temporomandibular disorders (TMD) on overall quality of life is substantial, causing significant functional limitations, such as difficulties in eating, speaking, or sleeping [18]. The chronic pain associated with TMD can also lead to psychological issues including depression, anxiety, and social isolation [22]. In addition to the physical and emotional toll, TMD imposes a significant economic burden due to medical expenses, loss of productivity, and reduced quality of life [23]. This impact on individuals and society underscores the need for effective management and therapeutic strategies. Consequently, a crucial treatment goal is to preserve or improve joint health in any dental intervention. Previous studies [18,20,24–29] have reported conflicting results regarding the effect of orthognathic surgery on TMD, and research on the optimal surgical approach for TMD remains limited [24–26]. Moreover, the existing literature lacks systematic reviews that comprehensively assess the impact of different orthognathic interventions and surgical modalities on TMD [18]. There is also no consensus in the literature regarding the role of orthognathic surgery in reducing or eliminating TMD symptoms. Some studies have associated orthognathic surgery with the onset of TMD, but its impact on signs and symptoms remains debatable [18]. Some authors argue that patients with joint disorders before surgery may experience significant worsening of symptoms afterward [27], while others highlight a 10–12% risk of increased joint symptoms following surgery [20,28]. Studies examining the variation of TMD in patients undergoing orthognathic surgery for open bite correction have found that TMD did not significantly change after the intervention [29]. Wolford et al. [30] argue that individuals who already have temporomandibular joint (TMJ) dysfunction before treatment are more likely to experience worsening conditions after orthognathic surgery, particularly following mandibular advancement. In the sample we analyzed, no patient showed significant deterioration in joint health; rather, overall symptoms decreased or remained unchanged. Specifically, the number of patients with joint clicks decreased, as did the presence of TMJ pain, pain in masticatory and cervical muscles, headaches, and parafunctions such as clenching and bruxism. The only parameter that remained unchanged was episodes of joint locking: three patients experienced this before surgery, and three patients reported a single episode after surgery. The collected data were statistically analyzed using the McNemar Test to assess whether our treatment influenced the outcomes. For statistical purposes, values reported as “decreased” were considered as “absent”, indicating that the treatment trend was correct. From the statistical analysis, we can conclude that the changes observed are significantly associated with the treatment performed, except for the Locking variable. The maximum mouth opening values before and after the intervention decreased: the average initial value was 51.46 mm, while the final value was 46.82 mm. The statistical analysis also confirms a significant association between the data variation and the intervention. Despite the decrease observed in the follow-up, the value remains well within the physiological range of mouth opening, typically greater than 35–40 mm [31]. This decrease can be attributed to the fact that maximum mouth opening is measured as the distance between the upper and lower incisal edges: correcting an open bite naturally reduces this measurement. It would be interesting to assess these data over a longer period to determine if the reduction in opening is lasting or if it is due to the new muscular arrangement resulting from the treatment. The collected data indicate that not only did the majority of examined patients not experience worsening of temporomandibular disorders (TMD), but also that most benefited from orthognathic surgery in terms of joint health and function. The various components of the stomatognathic system are closely interrelated: by restoring proper static and dynamic occlusion, the neuromuscular system and consequently the joint system are rebalanced. A limitation of the study is represented from the short follow-up of data collected (t1). We also excluded other causes of TMD from the sample and we focused on occlusal main problems in order to obtain a more uniform sample. In the future, it would also be desirable to enhance the collected data with more precise investigations at various levels (such as joint imaging, electromyographic examinations, and postural assessments) to support the findings obtained.

5. Conclusions

Based on the collected data, the following clinical points summarize the outcomes and considerations of the procedure:

- Orthognathic surgery for correcting open bite does not negatively impact the temporomandibular joints (TMJ).
- The procedure can improve TMJ health in patients with open bite, with a significant reduction or disappearance of joint disorders post-treatment.
- Correcting an open bite and restoring physiological occlusion are essential for the proper functioning of the stomatognathic system.
- Achieving optimal results requires a correct treatment protocol, proper orthodontic preparation, and adequate surgical correction.
- Overall, the study data support the benefits of orthognathic surgery on TMJ health and functionality.
- Due to the complex etiology of temporomandibular disorders (TMD) and surgical challenges, results should be interpreted with caution, and further research is needed to confirm these findings.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

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References

1. Omami, G.; Miller, C.S. Imaging Evaluation of the Temporomandibular Joint. *Dent. Clin. N. Am.* **2024**, *68*, 357–373. [[CrossRef](#)] [[PubMed](#)]
2. Laskin, D.M. Temporomandibular disorders: The past, present, and future. *Odontology* **2007**, *95*, 10–15. [[CrossRef](#)]
3. Chisnoiu, A.M.; Picos, A.M.; Popa, S.; Chisnoiu, P.D.; Lascu, L.; Picos, A.; Chisnoiu, R. Factors involved in the etiology of temporomandibular disorders—A literature review. *Clujul Med.* **2015**, *88*, 473–478. [[CrossRef](#)] [[PubMed](#)]
4. Rangel, M.; Ferreira, M.V.; Dos Santos, M.T.B.R.; da Silva, C.B.G.; Romano, M.M.; Guaré, R.O. Temporomandibular disorder in individuals with spinal cord injuries. *J. Spinal Cord. Med.* **2024**, *47*, 70–76. [[CrossRef](#)]
5. Mauro, G.; Verdecchia, A.; Suárez-Fernández, C.; Nocini, R.; Mauro, E.; Zerman, N. Temporomandibular Disorders Management—What's New? A Scoping Review. *Dent. J.* **2024**, *12*, 157. [[CrossRef](#)]
6. Gesch, D.; Bernhardt, O.; Kirbschus, A. Association of malocclusion and functional occlusion with temporomandibular disorders (TMD) in adults: A systematic review of population-based studies. *Quintessence Int.* **2004**, *35*, 211–221. [[PubMed](#)]
7. Yadfout, A.; El Aoud, J.; Merzouk, N.; Slaoui Hasnaoui, J. Increasing Vertical Dimension of Occlusion (VDO): Review. *Clin. Cosmet. Investig. Dent.* **2024**, *16*, 135–142. [[CrossRef](#)]
8. Hsu, L.F.; Liu, Y.J.; Wang, S.H.; Chen, Y.J.; Chen, Y.J.; Yao, C.C.J. Orthodontic correction of acquired open bite with TMJ degeneration: A retrospective study of outcomes and stability. *J. Formos. Med. Assoc.* **2023**, *123*, 452–460. [[CrossRef](#)] [[PubMed](#)]
9. Caldas, W.; Conti, A.C.d.C.F.; Janson, G.; Conti, P.C.R. Occlusal changes secondary to temporomandibular joint conditions: A critical review and implications for clinical practice. *J. Appl. Oral. Sci.* **2016**, *24*, 411–419. [[CrossRef](#)]
10. Nielsen, I.L. Vertical malocclusions: Etiology, development, diagnosis and some aspects of treatment. *Angle Orthod.* **1991**, *61*, 247–260. [[CrossRef](#)]
11. Shapiro, P.A. Stability of open bite treatment. *Am. J. Orthod. Dentofac. Orthop.* **2002**, *121*, 566–568. [[CrossRef](#)] [[PubMed](#)]

12. Ngan, P.; Fields, H.W. Open bite: A review of etiology and management. *Pediatr. Dent.* **1997**, *19*, 91–98. [[PubMed](#)]
13. Subtelny, J.D.; Sakuda, M. Open-bite: Diagnosis and treatment. *Am. J. Orthod.* **1964**, *50*, 337–358. [[CrossRef](#)]
14. Jeong Choi, Y.; Suh, H.; Jin Park, J.; Hyun Park, J. Anterior open bite correction via molar intrusion: Diagnosis, advantages, and complications. *J. World Fed. Orthod.* **2023**, *13*, 2–9. [[CrossRef](#)]
15. Benetti, M.; Montresor, L.; Cantarella, D.; Zerman, N.; Spinass, E. Does Miniscrew-Assisted Rapid Palatal Expansion Influence Upper Airway in Adult Patients? A Scoping Review. *Dent. J.* **2024**, *12*, 60. [[CrossRef](#)] [[PubMed](#)]
16. Arnett, G.W.; D’Agostino, A.; Grendene, E.; McLaughlin, R.P.; Trevisiol, L. Combined orthodontic and surgical open bite correction: Principles for success. Part 2. *Angle Orthod.* **2022**, *92*, 431–445. [[CrossRef](#)] [[PubMed](#)]
17. Arnett, G.W.; Trevisiol, L.; Grendene, E.; McLaughlin, R.P.; D’Agostino, A. Combined orthodontic and surgical open bite correction: Principles for success. Part 1. *Angle Orthod.* **2022**, *92*, 161–172. [[CrossRef](#)]
18. Abdul, N.S.; Minervini, G. Prevalence of Temporomandibular Disorders in Orthognathic Surgery patients: A systematic review conducted according to PRISMA guidelines and the Cochrane Handbook for Systematic Reviews of Interventions. *J. Oral. Rehabil.* **2023**, *50*, 1093–1100. [[CrossRef](#)] [[PubMed](#)]
19. McNemar, Q. Note on the sampling error of the difference between correlated proportions or percentages. *Psychometrika* **1947**, *12*, 153–157. [[CrossRef](#)]
20. Abrahamsson, C. Masticatory function and temporomandibular disorders in patients with dentofacial deformities. *Swed. Dent. J. Suppl.* **2013**, *231*, 9–85. [[PubMed](#)]
21. Pembury Smith, M.Q.R.; Ruxton, G.D. Effective use of the McNemar test. *Behav. Ecol. Sociobiol.* **2020**, *74*, 133. [[CrossRef](#)]
22. Storari, M.; Zerman, N.; Salis, B.; Spinass, E. Chronic Facial Pain in Fibromyalgia: May ElectroMagnetic Field Represent a Promising New Therapy? A Pilot Randomized-Controlled Study. *Int. J. Environ. Res. Public. Health* **2022**, *20*, 391. [[CrossRef](#)] [[PubMed](#)]
23. Minervini, G.; Franco, R.; Marrapodi, M.M.; Fiorillo, L.; Cervino, G.; Cicciù, M. Economic inequalities and temporomandibular disorders: A systematic review with meta-analysis. *J. Oral. Rehabil.* **2023**, *50*, 715–723. [[CrossRef](#)] [[PubMed](#)]
24. Zaroni, F.M.; Cavalcante, R.C.; João da Costa, D.; Kluppel, L.E.; Scariot, R.; Rebellato, N.L.B. Complications associated with orthognathic surgery: A retrospective study of 485 cases. *J. Craniomaxillofac. Surg.* **2019**, *47*, 1855–1860. [[CrossRef](#)]
25. Pachnicz, D.; Ramos, A. Mandibular condyle displacements after orthognathic surgery—An overview of quantitative studies. *Quant. Imaging Med. Surg.* **2021**, *11*, 1628–1650. [[CrossRef](#)] [[PubMed](#)]
26. Ploder, O.; Sigron, G.; Adekunle, A.; Burger-Krebs, L.; Haller, B.; Kolk, A. The effect of orthognathic surgery on temporomandibular joint function and symptoms: What are the risk factors? A longitudinal analysis of 375 patients. *J. Oral. Maxillofac. Surg.* **2021**, *79*, 763–773. [[CrossRef](#)] [[PubMed](#)]
27. Wolford, L.M.; Reiche-Fischel, O.; Mehra, P. Changes in temporomandibular joint dysfunction after orthognathic surgery. *J. Oral. Maxillofac. Surg.* **2003**, *61*, 655–660; discussion 661. [[CrossRef](#)]
28. Gesch, D.; Bernhardt, O.; Kocher, T.; John, U.; Hensel, E.; Alte, D. Association of malocclusion and functional occlusion with signs of temporomandibular disorders in adults: Results of the population-based study of health in Pomerania. *Angle Orthod.* **2004**, *74*, 512–520. [[CrossRef](#)]
29. Aghabeigi, B.; Hiranaka, D.; Keith, D.A.; Kelly, J.P.; Crean, S.J. Effect of orthognathic surgery on the temporomandibular joint in patients with anterior open bite. *Int. J. Adult Orthodon. Orthognath. Surg.* **2001**, *16*, 153–160. [[CrossRef](#)]
30. Wolford, L.M.; Karras, S.; Mehra, P. Concomitant temporomandibular joint and orthognathic surgery: A preliminary report. *J. Oral. Maxillofac. Surg.* **2002**, *60*, 356–362. [[CrossRef](#)] [[PubMed](#)]
31. Dworkin, S.F.; LeResche, L. Research diagnostic criteria for temporomandibular disorders: Review, criteria, examinations and specifications, critique. *J. Craniomandib. Disord.* **1992**, *6*, 301–355. [[PubMed](#)]

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