
Mandibular repositioning in adult patients – an alternative to surgery? A two-year follow-up

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Background: Adult patients presenting with skeletal discrepancies may refuse surgical intervention.

Materials and methods: Thirty-two patients who declined orthognathic correction of their maxillo-mandibular dysplasia and who were without signs of temporomandibular dysfunction (TMD) were offered mandibular repositioning as a non-invasive alternative. Simulating a skeletal correction, it was explained that the approach was based on results described in case reports.

Before commencing treatment, initial records, lateral and frontal head films, study casts and photos were obtained (T0) and the mandible was repositioned to camouflage a retrognathic skeletal discrepancy or a mandibular transverse asymmetry by means of an occlusal build-up using Triad™ gel.

Results: Three months later (T1), 23 patients had adapted to the new occlusion reflected by an absence of functional disturbance and without fracture of the composite occlusal build-up. Mandibular position in these patients was maintained by additional orthodontic treatment and an adjustment of the occlusion to the built-up postured position (T1). The skeletal changes occurring during repositioning were assessed on sagittal and frontal head films while intra-articular changes occurring during a two-year follow-up period (T2) were evaluated on images constructed from CBCT scans. No significant change, either in the direction of relapse or in the direction of further normalisation of condylar position, were observed during the two-year observation period.

Conclusion: Mandibular repositioning is a non-invasive intervention that may be considered a valid alternative to surgery in selected patients. Morphological variables from the radiographs taken at T0 and the results of the initial clinical evaluation of dysfunction yielded only vague and insignificant indicators regarding the predictability of the adaptation. A CBCT scan at T0 might have contributed to the identification of the patients who would likely accept the repositioning.

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Introduction

The treatment of sagittal and transverse skeletal discrepancies by functional appliances in young patients in order to attempt growth modification is a recognised management approach.¹⁻³ Forward repositioning of the mandible in patients with a Class II malocclusion has been considered feasible during the pubertal and post-pubertal period as modelling of

the temporomandibular area has been demonstrated to adapt to condylar displacement.⁴ The treatment of severe sagittal and transverse skeletal deviations in adult patients has, however, generally been referred for orthognathic surgery as a functional repositioning of the mandible will invariably lead to a dual bite. The centric relation position is commonly used as a reference by prosthodontists⁵⁻⁷ and a dual bite has been

perceived as an initiating risk for temporomandibular disorders.⁸ Consequently, mandibular repositioning has been considered inadvisable and shown to be detrimental by several authors.⁸⁻¹⁰ A spontaneous repositioning of the condyle is often observed when bite planes are inserted in patients with temporomandibular joint dysfunction (TMD),^{11,12} but a causal relationship between TMD and condylar position remains highly controversial.¹²⁻¹⁴

Møller and Bakke¹¹ suggested that when the proprioceptive input from the occlusion is removed, the mandible will often find a neutral position. For this reason a bite plane will frequently lead to a combined relief of the TMD symptoms and occlusal changes that may require orthodontic treatment, prosthetic rehabilitation or even surgery to achieve new occlusal stability.

While a consensus regarding the result of forward positioning of a retrognathic mandible before and during puberty and related condylar growth has not been reached, signs of glenoid fossa remodelling and condylar adaptation have been reported following injuries, supporting the possibility in humans.^{15,16}

Several studies and case reports indicate that a dual bite can be related to symptoms from the masticatory system, identified as muscular pain, headache and TMD.^{17,18} This was verified by Okeson, who claimed that a position anterior to the most orthopaedically stable position would require increased activity of the lateral pterygoid muscle.¹⁹ However, Murray performed an EMG study of 154 asymptomatic subjects and found no lateral pterygoid muscle hyperactivity in a clinically determined postural jaw position.²⁰

Although it has been demonstrated that patients with TMD may have condylar displacement, CT scans of a large group of patients presenting with a neutral occlusion or Class I, II and III malocclusion without any joint symptoms, demonstrated a significant variation in condylar position.²¹⁻²³ Existing knowledge related to condylar position therefore does not exclude the possibility of a repositioning of the mandible. The lack of evidence for mandibular repositioning is most likely due to the multifactorial aetiology of TMD. It has, however, been demonstrated that a simple chair-side intraoral qualitative sensory test is sufficient to determine if a more sophisticated somatosensory evaluation is necessary.

Aims

As there is no consensus regarding mandibular repositioning in adult patients, the results of non-invasive mandibular advancement were assessed in a group of patients who were earmarked for orthognathic surgery, but who refused. The skeletal changes caused by the repositioning were evaluated on lateral and frontal head films, while skeletal and intra-articular changes occurring during the two years following the repositioning were evaluated on CBCT images. Based on the results a hypothesis regarding the predictability of the acceptance was formulated.

Patients and methods

Thirty-four Caucasian patients, 12 males and 22 females, aged between 17 and 54 (mean age 30.7), characterised by mandibular retrognathism and/or occlusal asymmetry, refused the recommended surgical intervention. The patients came from three different clinics over a period of three years. Two patients refused both surgery and mandibular repositioning. The 32 participating patients were informed that the suggested treatment was based on case reports and without scientific evidence. Repositioning of the mandible was preferred rather than the compromise of only dental displacement. Informed consent for the publication of the results was obtained from all patients.

Lateral and frontal head films with the patient in habitual occlusion were available for all patients at the start of treatment (T0). While repositioning the mandible to simulate maximal occlusal contacts in a normal sagittal and transverse relationship (Figure 1), a light-curable transparent composite (Triad Gel™, Dentsply Sirona, PA, USA) was added to the buccal cusps of the lower molars and premolars and cured. In one patient, a deep bite required correction before the mandibular repositioning. Based on the occlusion, the maximum sagittal anterior advancement was 4 mm, while the maximum transverse repositioning (midline correction) was 3 mm. Bite opening was kept to a minimum, by leaving one intermaxillary contact.

Three months after repositioning (T1), the patients were evaluated in order to register their adaptation to the new mandibular position. Acceptable adaptation was defined as: (1) No reported discomfort; (2) three or fewer fractures of the Triad Gel™; and (3) no pain on palpation of the TMJ, the masseter and

the temporalis muscles. In addition, the patients reported an absence of symptoms from the inferior lateral pterygoid muscle when tested for contraction, as described by Okeson.²⁴

A cone-beam computer tomography (CBCT) image with a 12" FOV was taken of the 23 patients who reacted positively to the mandibular repositioning (T1), and orthodontic treatment aimed at establishing and maintaining the occlusion in the protruded or laterally-shifted position was started. During treatment, which was performed with segmented fixed appliances, the on-lays used for repositioning were gradually removed and, when considered necessary, intermaxillary elastics applied. Patients who did not adapt to the repositioning after three months were left in their original habitual occlusion and accepted a compromise result or discontinued treatment.

The patients who accepted the repositioning of the mandible were followed for two years (T2), whereupon a second CBCT was taken in maximal intercuspation. The skeletal changes were assessed by a comparison of cephalometric variables at T0, T1 and T2 on the sagittal and frontal head films (Table I, Figure 2). Condylar position and the skeletal changes were assessed on a second CBCT scan taken with the patient in maximal intercuspation.

The skeletal changes in the sagittal and frontal variables were based on measurements obtained from the head films taken at T0 and the CBCT-constructed images taken at T1 and T2. The changes in condylar position at T1 and T2 were assessed using the variables defined

by Vitral et al.²³ on CBCT cross-sectional images of temporomandibular articulation perpendicular to the condylar axis (Table I, Figure 3).

Statistics and error of the method

The inter-examiner error of the method was evaluated by repeated measurements of 10 condyles performed by two of the authors (GF and PM) and expressed by the Dahlberg formula²⁵ and intra-class correlation according to Shrout and Fleiss.²⁶

The repositioning skeletal changes were checked for normality (Kolmogorov-Smirnov test) and, over the following two years, were evaluated with a Student *t*-test for paired data. The same test was applied to



Figure 1. Triad Gel™ (Dentsply) applied to the buccal cusps of the lower posterior teeth.

Table I. Variables.

<i>Lateral cephalometrics</i>	
FH-NPg	Angle: Frankfurt Horizontal / Nasion-Pogonion Line
A-NPg	Distance between A point and Nasion-Pogonion
SNB	Angle: Sella-Nasion- B point
ANB	Angle: A point-Nasion- B point
SN-GoGn	Angle: Sella-Nasion / Gonion-Gnathion
<i>Postero-Anterior Cephalometrics</i>	
ML-ANS-Me	Angle: Facial Midline / Anterior Nasal Spine Menton
<i>Lateral CBCT of Temporomandibular Joint</i>	
PJS	Posterior Joint Space
SJS	Superior Joint Space
AJS	Anterior Joint Space
Po-C	Distance between Porion and most Posterior Condylar Point

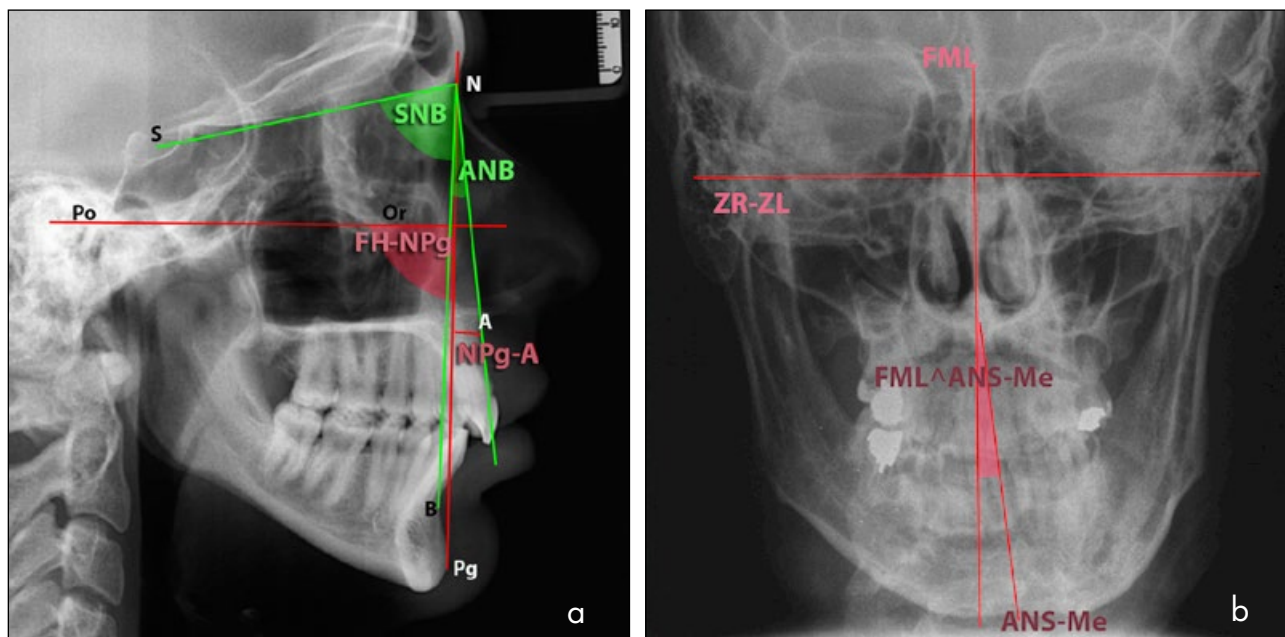


Figure 2. (a) Cephalometric measurements used for assessing the skeletal changes in Class II patients, (b) the posteroanterior cephalometric measurements used in asymmetric cases.

the evaluation of the intra-articular changes between T1 and T2. The impact of mandibular repositioning was assessed by comparing the intra-articular changes between T1 and T2. The pretreatment skeletal patterns of those accepting and those not tolerating the repositioning were finally compared with a Mann-Whitney U test for non-related variables.

Results

For all the variables and both of the cephalometric and the CBCT measurements, the error of the method was considerably lower than the standard deviation of the changes evaluated, and therefore not considered clinically relevant. Furthermore, the intra-class correlation showed excellent agreement ($R > 0.9$) (Table II).

Immediate acceptance

By clinical inspection three months after repositioning at T1, 23 patients out of 32 had adapted to the new mandibular position: 11 out of 17 patients with anterior repositioning corresponded to 64% and 12 out of 15 of patients who were repositioned transversely corresponded to 80%. Nine patients, six with an anterior repositioning and three with transverse repositioning, did not show positive adaptation after three months. Of these, five had frequent breakages

of the bonded material, indicating pre-contacts on the on-lays, while three patients reported discomfort, although no muscle soreness could be verified upon palpation. One patient who was repositioned

Table II. Error of the method (EotM) and intraclass correlation (ICC).

	PJS	SJS	AJS	Po-C
EotM (mm)	0.23	0.34	0.20	0.32
ICC	0.947	0.961	0.983	0.968

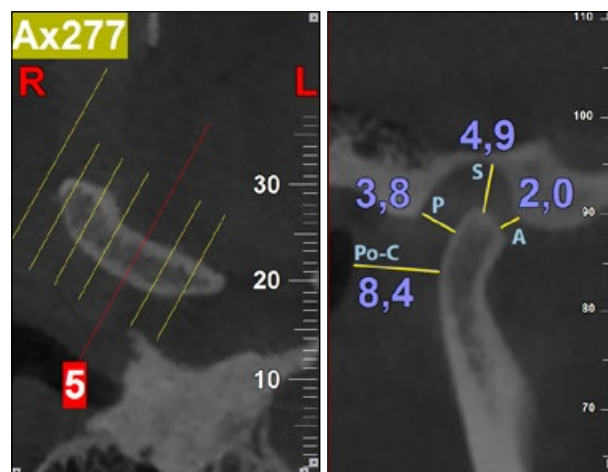


Figure 3. Temporomandibular measurements taken on CBCT cross sectional images of the temporomandibular articulation perpendicular to the condylar axis according to Vital.²³ The measurements allow access to condylar position within the articular fossa: P- posterior space, S- superior space, A- anterior space, Po-C- the distance between the posterior surface of the condyle and porion.

Table III Lateral cephalometric variables in patients with anterior repositioning of the mandible.

	FH N-Pg		A N-Pg		SNB		ANB		SN-GoGn	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
T0	87.18	2.34	4.45	3.13	75.30	1.79	6.11	2.37	33.67	6.81
T1	88.59	2.17	2.69	2.78	76.77	1.99	4.11	2.42	34.91	5.97
T2	88.76	2.41	2.65	2.50	76.68	1.85	4.18	2.10	33.43	5.63
T1-T0	1.41	0.50	-1.75	0.55	1.47	0.36	-2.00	0.83	1.24	1.05
T2-T0	1.58	0.81	-1.79	0.99	1.38	0.45	-1.93	1.14	-0.25	2.196
T2-T1	0.17	0.68	-0.04	0.55	-0.09	0.37	0.07	0.64	-1.48	1.92

transversely (asymmetry correction) developed pain in the TMJ on the side to which the mandible had been repositioned. The patient, who did not continue treatment, was of similar age to those who accepted treatment.

Long-term adaptation (Figures 4–7)

The observed changes in the cephalometric parameters of those patients who completed treatment reflected a reduction in the skeletal discrepancies (Tables III and IV). All obtained good lateral intercuspation and none developed TMD signs or symptoms. The changes in the head film measurements following the repositioning period from T0 to T1 were variable, but all approximated normal values. However, in the majority of cases, there was a minor relapse tendency between T1 and T2. In the patients shown in Figures 5 and 6, the orthodontic treatment led to additional improvement of the skeletal relationships. Figure 4 indicates that the levelling of the lower arch and proclination of the lower incisors allowed for better lip function and a slight forward displacement of the mandible. In the patient in Figure 5, the intrusion following repositioning resulted in an anterior rotation of the mandible bringing pogonion further forward. The bite opening resulting from the repositioning produced by the Triad gel, and from the orthodontic treatment delivered to obtain a good occlusion, tended to relapse during the two years of review.

The assessment of condylar position on the CBCT images allowed for measurements with a slice plane interval of 0.3 mm. Consequently, modifications in condyle position less than 0.3 mm were not detected. A comparison of condylar position obtained after three months of repositioning (T1) with that obtained after two years (T2) revealed no significant difference in the group in which sagittal repositioning occurred,

Table IV Posteroanterior cephalometric variables in patients with transversal repositioning of the mandible.

	Mean	SD
T0	4.68	1.25
T1	1.26	0.98
T2	1.25	0.96
T1-T0	-3.42	0.77
T2-T0	-3.43	1.19
T2-T1	-0.01	0.69

whereas the changes in the patients with transverse repositioning were more variable (Tables V and VI). The greatest change was in the patient shown in Figure 5, in which the left condyle was positioned 1 mm more posteriorly at T2 than at T1. This indicated a relapse change of transverse repositioning of the mandible, further indicated by the lower midline moving to the right at T1 with respect to T0. The opposite tendency is seen in the patient shown in Figure 6, in which the left condyle was found in a more anterior position at T2. This reflected further improvement of mandibular positioning centering toward the right side. The morphology of the condyle and of the bony contour of the articular fossa was found unchanged in all but one patient, in whom a bony tubercle on the posterior wall of the glenoid fossa (Figure 7) had developed between T1 and T2. This was explained by mandibular repositioning to the right having caused anterior movement of the left condyle greater than 3 mm. At T2, the patient was symmetrical and exhibited a posterior space in the left TMJ of 1.5 mm, indicating a possible remodelling of the posterior wall of the glenoid fossa.

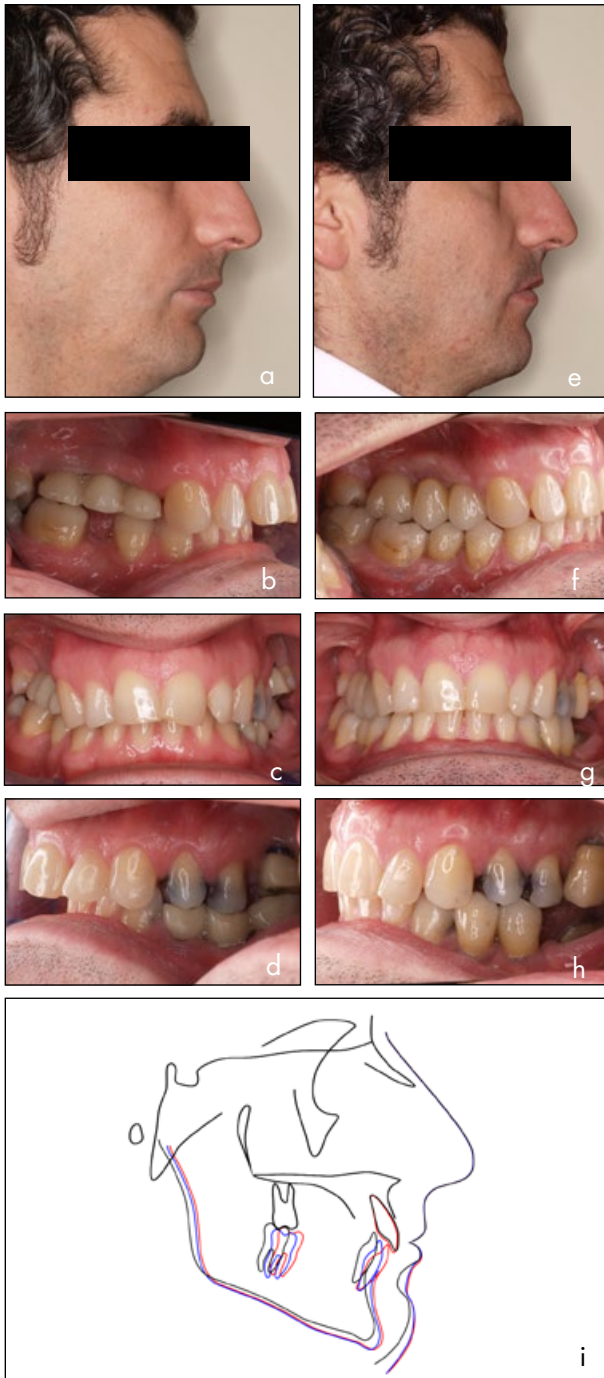


Figure 4. (a-d) A thirty-seven-year-old patient before treatment. The patient had crowns on implants with uneven vertical heights leading to a canted occlusal plane. There was a full unit Class II relationship with a large overjet due to a retruded mandible. (e-h) A 4 mm anterior repositioning of the mandible increased the height of the lower face. During orthodontic treatment the lower incisors were proclined and the space between the upper right premolar and canine was closed. Treatment lasted 14 months, and radiographs two years following mandibular repositioning indicated that the profile had greatly improved, overjet was normal and the canine relations were Class I. Replacement of the left lower molar with an implant is planned. (i) The superimposition of the tracing at T0 (black), T1 (blue) and T2 (red). The proclination of the lower incisors has changed lip function and allowed for the mandible to be displaced further anteriorly.



Figure 5. (a-d) A twenty-seven-year-old woman with a severe skeletal Class II relationship, an increased overjet, a posteriorly positioned mandible and severe lower crowding. (e-h) Treatment comprised a mandibular advancement of 4 mm, intrusion of the upper posterior teeth using TADs as anchorage and the extraction of three premolars and one compromised molar. Following treatment a significant improvement of the profile can be appreciated. (i) Tracings representing T0, T1 and T2. The intrusion of the maxillary teeth led to an anterior rotation of the mandible, which brought pogonion further forward.



Figure 6. (a–d) A forty-six-year-old female patient demonstrating skeletal asymmetry with a deviation of the chin to the left. The lower dental midline deviated 4 mm to the left leading to a Class II canine relation on the left side. (e–h) The patient had the mandible repositioned to the right. The crowns of the right canine and premolar were modified and an implant replaced the upper right second premolar. Orthodontic treatment also included expansion of the left lower segment in order to maintain occlusal contacts in the new mandibular position. At two years follow-up, facial symmetry was greatly improved, the dental midlines were coincident and a canine Class I was present on the left side. Prosthetic rehabilitation was still to be completed. (i) Posteroanterior radiograph illustrating the changes that occurred in the frontal plane.



Figure 7. (a–d) Forty-one-year-old male patient characterised by a severe asymmetry with a deviation of the mandible to the left and a full cross bite on the same side. A Class III molar relationship was present on the right side. (e–h) The patient’s mandible was repositioned to the right and orthodontic treatment was also performed including an asymmetric upper expansion and lower contraction in the right side, transverse leveling of the occlusal plane and space closure on the lower right quadrant by anterior retraction. Implants were placed in the lower left quadrant. Following treatment, the facial symmetry was improved, and a centered occlusion with the midlines centered and a Class I canine relation was achieved on the right side. Temporary crowns were still present on the implants. (i) The frontal radiographs demonstrated the changes and at T2 also the inserted implants. (j–l) Eight months from treatment start, the mandible was repositioned and the midlines were coincident. The disocclusion, due to repositioning, had contributed to the Class III correction. Once the transversal position has been accepted and stabilised, the following treatment consisted mostly of the sagittal correction, in which the implants used to replace teeth 3.6 and 3.7 were used as anchorage.

Table Va. Condylar position at T1 and T2 in the patients with sagittal repositioning.

	Right condyle								Left condyle							
	Po-con		POST		SUP		ANT		Po-con		POST		SUP		ANT	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
T1	8.66	1.36	3.89	0.72	4.23	0.98	1.48	0.27	8.98	1.84	4.39	1.23	5.01	0.91	1.60	0.61
T2	8.29	1.26	3.80	0.93	4.10	1.20	1.77	0.27	8.52	2.03	4.26	1.30	4.39	1.22	1.81	0.62
Δ	-0.37	0.61	-0.09	0.56	-0.13	0.35	0.29	0.33	-0.46	0.64	-0.12	0.28	-0.56	0.98	0.19	0.19

Table Vb. Condylar position at T1 and T2 in the patients with transverse repositioning.

	Rotating condyle								Orbiting condyle							
	Po-con		POST		SUP		ANT		Po-con		POST		SUP		ANT	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
T1	6.91	1.49	2.11	0.75	3.01	0.93	2.11	0.90	7.20	1.54	3.07	0.98	3.54	1.05	2.07	0.83
T2	6.70	1.33	2.14	0.70	3.21	0.83	2.33	0.63	7.31	1.79	3.36	1.20	3.56	0.98	1.91	0.65
Δ	0.19	0.41	-0.03	0.24	-0.18	0.36	-0.20	0.38	-0.10	0.89	-0.26	0.65	-0.01	0.60	0.14	0.41

Discussion

The present study was performed for the purpose of evaluating whether a repositioning of the mandible could be considered a valid alternative to surgery in patients with a mandibular retrognathic skeletal discrepancy. A repositioning of the mandible will inevitably lead to an intra-articular displacement of the condyle. The present study therefore focused on the acceptance of the patients to the new forced mandibular position, and on the changes within the temporomandibular joint over time.

Based on studies carried out on mandibular tomograms by Pullinger et al.,¹⁷ a non-concentric condyle-fossa relationship has been associated with abnormal temporomandibular joint function. However, the authors also reported a large variation of the RCP-ICP slide in an asymptomatic population with different malocclusions. The weakness of the paradigm regarding RCP-ICP distance was further substantiated by Rodrigues et al.,²² who performed tomographic studies of temporomandibular joints in patients with a Class II div. 1 subdivision malocclusion. No correlation could be confirmed between the occlusal asymmetry and an asymmetry of the joint. In an additional study, it was demonstrated that a significant difference between the right and left joint was often present in individuals with a neutral occlusion. However, the conclusion may also be related to the weakness in the applied measurements, as even well-constructed CBCT images did not allow for acceptable reproducibility of measurements below 0.3 mm.

In the present study, 23 patients out of the 32 observed adapted well to the repositioning of the mandible according to the clinical analysis performed after three months. A prediction identifying which patients could accept the repositioning would, according to the statement by Seligman and Pullinger,¹⁸ not be possible as it was claimed that neither guidance nor any kind of parafunction is correlated with temporomandibular disorder or a variation in an RCP-ICP slide. The dissociation from the classical concept regarding condylar position was recently confirmed by the American Association for Dental Research, which stated that temporomandibular disorders do not necessarily reflect malpositioning of the condyle.²⁷

As there is no general consensus regarding the treatment approach presented in the present paper, no hypothesis could be formulated. The paper may best be considered a report of a novel method for managing a mandibular dysplasia without surgery. The repositioning is a cheap, minimally-invasive method, which may in some cases replace a more expensive and more invasive surgical intervention. However, a test period associated with a temporary build-up is diagnostically important as a dual bite may be generated and associated with severe symptoms.⁸ To avoid this, a reflex-liberating splint is frequently used as part of the pre-surgical establishment of condylar position by removing the proprioceptive input from the occlusion. This approach has recently been supported by a randomised, controlled trial, which confirmed the benefits of freeing occlusal

input by means of a bite plane splint.¹² Nevertheless, a review concluded that the prediction of the post-surgical condylar position was unreliable.⁷

The treatment suggested in the present report is simple, less invasive and arguably successful. A lack of acceptance was identified by muscle symptoms, the development of TMD or severe bruxism on the on-lay leading to loss or fracture of the Triad® gel. This material was chosen as it is known to fracture easily when submitted to substantive forces, like those generated during bruxism. Patients should be informed and accept the experimental nature of the repositioning as an alternative to orthognathic surgery. With a success rate of 68% in the group of patients described in the present paper, mandibular repositioning could be considered a valid alternative before accepting surgery as the prime strategy for the treatment of mandibular retrognathism and asymmetries in adult patients. This is illustrated in Figures 4–7, in which four of the cases treated by repositioning are presented showing clinical intraoral images, along with faces and cephalometric images before and after treatment. The possibility of adaptation of the TMJ was demonstrated by Lund, who assessed post-fractural changes and found that compensatory remodelling of the fractured condyles occurred in 48% of the individuals studied.²⁸

Based on the comparison of the cephalometric values at T0 from the successful and the non-successful patients, only mandibular inclination was different, which might indicate that patients with a stronger muscle matrix reacted more negatively to repositioning. However, a retrospective analysis of abrasion facets as a possible predictor did not corroborate this hypothesis. Whether a more detailed functional analysis involving jaw tracking and EMG would determine the feasibility of repositioning is a subject of speculation and calls for further research.

Based on the present study, it is not possible to predict which patients are able to accept mandibular repositioning, and so invasive occlusal adjustment should be avoided until after a test period.

Conclusion

The present paper is not testing a hypothesis, but illustrates that the repositioning of the mandible might be a treatment procedure that could be offered as an acceptable, non-invasive alternative to surgery in patients in whom a sagittal or transverse skeletal discrepancy is localised to the mandible.

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