

Morphological Changes of Condyles and Helkimo Clinical Dysfunction Index in Patients Treated with Herbst - Orthodontic Appliance

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This study evaluated the morphological changes in the temporomandibular joint (TMJ) condyles and calculated the Helkimo clinical dysfunction index (CDI) in adolescents with Class II Division 1 malocclusion and mandibular retrognathism treated with the Herbst appliance (phase I) and fixed orthodontic appliances (phase II). Thirty-two consecutive adolescents underwent phase I, and 23 completed phase II. The TMJs were evaluated qualitatively using magnetic resonance imaging (MRI) at the beginning of treatment (T₁), during phase I (T₂), at the end of phase I (T₃) and at the end of phase II (T₄). The CDI was calculated at T₁, T₃ and T₄. From T₁ to T₃ (p=0.326), there were no changes in condyle morphology in 86.0% of the TMJs. From T₃ to T₄ (p<0.05) and T₁ to T₄ (p<0.05), changes occurred in 39.1% and 43.4% of the condyles. No significant changes in CDI occurred from T₁ to T₃, T₃ to T₄ and T₁ to T₄ (p=1.000; 86.6%, 76.2% and 76.2% concordance). After phase I, there were practically no changes in condyle morphology. At the end of phase II, a mild flattening was observed in some condyles. It may be concluded that no significant changes occurred in CDI after both treatment phases.

Introduction

Class II malocclusion associated with mandibular retrognathism may be treated using orthopedic functional appliances in the first phase of treatment to advance the mandible and to improve its anteroposterior adjustment during growth (1-9). In the second phase of treatment, fixed orthodontic appliances are used to refine occlusion (1,9). The responses of the temporomandibular joints (TMJs) treated using this method are controversial, which has led to the conduction of studies using the three-dimensional finite element method (10) as well as analyses in groups of experimental animals (11) or humans beings (1-9).

Functional analyses of the masticatory system (12,13) by means of clinical evaluations, combined with morphological changes in the TMJs diagnosed using imaging tests, have been included in some studies (1,6-9) to elucidate the effects of treatment using the Herbst appliance.

Studies using panoramic radiographs, computer tomography (CT) scanning and transpharyngeal exposure (6) aimed at evaluating TMJs after Herbst therapy. However, radiographs and CT scans are of limited value in imaging the condyle cartilage. On the other hand, magnetic resonance imaging (MRI) is noninvasive, does not require ionizing radiation for image acquisition and provides direct visualization of the disc and joint structures (14-19).

Investigations using MRI have identified the

mechanisms of TMJ remodeling in patients treated with the Herbst appliance (7,8). However, in isolated cases, some authors have reported structural bone changes in different condyle morphologies after such treatments (20,21).

This prospective longitudinal study assessed possible changes in the condyle morphology of TMJs and calculated the Helkimo clinical dysfunction index (CDI) in adolescents with Class II, Division 1 mandibular retrognathism who were treated with the Herbst appliance followed by fixed orthodontic appliances.

Material and Methods

This study was approved by the Ethics Committee of the Federal University of São Paulo (Process #0428/09), and all patients or their guardians signed an informed consent form.

In this study, 32 consecutively white adolescents (16 male and 16 female) were treated using a Herbst appliance for 12 months (phase I). Mean pre-treatment age was 12.8 ± 1.2 years (range: 10.9 to 15.8 years). Immediately after completing phase I, 23 of the 32 adolescents (13 male and 10 female) continued treatment with a fixed orthodontic appliance (phase II) using pre-adjusted 0.022 x 0.028-inch brackets (mean phase II duration = 2.2 ± 0.9 years). Phases I and II were performed by the same orthodontist.

Patients with the following characteristics were enrolled

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in the study: clinical appearance of a retrognathic mandible with ANB angle greater than 4 degrees; Angle Class II, Division 1 malocclusion with permanent dentition; mean overjet of 8.6 ± 2.1 mm (range: 5 to 13 mm); maximum of skeletal pubertal growth peak evaluated by the hand and wrist X-rays (22).

The first phase consisted of treatment with a modified Herbst appliance (metal crowns, bands, upper Hyrax expander and lower lingual arch - Fig. 1). As transversal maxillary deficiency frequently occurs in Class II malocclusions (23), rapid maxillary expansion was performed during the first 2 weeks after placement of the Herbst appliance (one turn on the first day and half a turn on subsequent days until clinical correction was achieved (1)).

The mandible was advanced up to 6 mm at the beginning of the treatment. When necessary, supplementary advances of 2 to 3 mm were achieved in the third month. In all 32 adolescents, treatment with the Herbst appliance (1,7,8) resulted in Class I or overcorrected Class I dental arch relationships.

In phase II, an Interlandi headgear (IHG) was used during leveling to reduce possible loss of anchorage on maxillary molars, which had been moved distally during treatment with the Herbst appliance (3). At the end of phase II, all 23 patients showed good occlusal adjustment and functional occlusion.

MRI of the right (R) and left (L) TMJs with the mouth closed (MC) and mouth open (MO) were taken at four time points during treatment: immediately before the beginning of phase I (T_1), 8-10 weeks after Herbst appliance placement (T_2), at the end of phase I (T_3) and at the end of phase II (T_4).

A Philips Gyroscan ACS-NT superconductor (Philips, The Netherlands), with magnetic field intensity of 1.5 Tesla, and bilateral TMJ surface coils were used. MRI was performed using T1-weighted (w) axial planning images; T1 TSE sagittal oblique images with closed and open mouth (TR/TE: 1300/70 ms, FOV: 16 cm, NSA: 4, Matrix: 204 x 512); T2 TSE sagittal oblique images with closed and open mouth (TR/TE: 4300/120 ms, FOV: 16 cm, NSA: 4, Matrix: 204 x 512); Proton density FFE sagittal oblique (TR/TE: 60/14 ms, FOV: 16 cm, NSA: 4, Matrix: 212 x 512) and T1 TSE coronal

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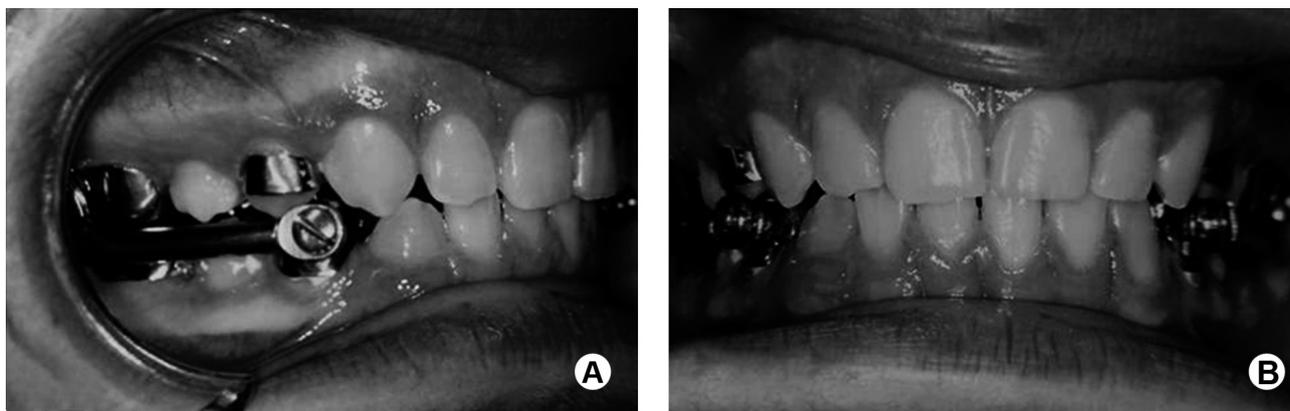


Figure 1. Right side view (A) and front view (B). Modified Herbst appliance (metal crowns, bands, upper Hyrax expander and lower lingual arc).

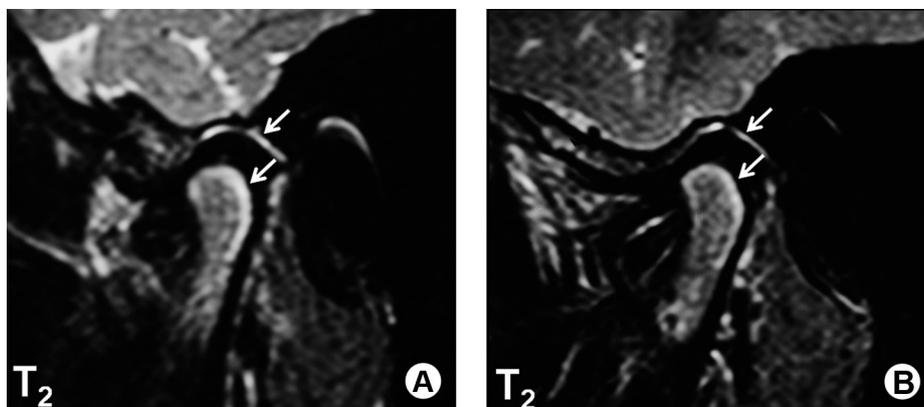


Figure 2. Patient 9 - MRIs of left (A) and right (B) TMJs at T_2 showed an area with hypersignal in posterior superior regions of condyles and supradiscal region, which confirmed the increase of bone remodeling in the region.

images (TR/TE: 580/15 ms, FOV: 16 cm, NSA: 4, Matrix: 204 x 512). In all images, the thickness/increment was 1.5/0.1 mm except in the sagittal oblique sequence in the Proton images, in which the thickness/increment was 2.8/-1.3 mm.

Parasagittal MRIs were taken perpendicularly to



Figure 3. Patient 19 - MRIs of right TMJ. There was a significant change in condyle morphology (degenerative bone disease) at T₁ (A) and it improved with treatment at T₃ (B), remaining stable when evaluated at T₄ (C).

the condyle long axis and the coronal MRIs parallel to the condyle long axis. In each sequence, 16 slices were obtained (8 for each TMJ). The MRIs were examined under 2x magnification.

The MRIs were interpreted visually at the four time points (T₁, T₂, T₃ and T₄) by 2 observers ('A' and 'B') using an MRI protocol to better define criteria for interpretation. As the 2 observers had been trained differently because of their backgrounds, they were retrained for 4 months with images not included in this study, to achieve more standardized readings. Images for this study were then interpreted 3 times by observer A and once by observer B (who also gave the final diagnosis). A double-blind procedure was applied. Observer A's interpretations, performed at regular 15-day intervals, were divided into preliminary and final readings. The preliminary readings consisted of one interpretation before observer A received training (pre-training) and one after training (post-training). Observer A's third reading was considered the final interpretation. Overall interobserver agreement was calculated as the proportion of the joints for which observer A's final interpretation and observer B's interpretation agreed.

At T₁, T₃ and T₄, condyle morphology was evaluated using the MRIs acquired at T₁ (weighted parasagittal and coronal scans) in the MC position (14), and classified as normal (NL), when the articular component was rounded with a soft and intact cortex, or remodeled (R), when there was a flattening (anterior and/or superior slope, posterior - parasagittal images; contour of the cortical bone of the articular surface from lateral to medial area of the condyle - coronal images), or variation of the morphology but an intact cortex. Degenerative bone disease (DBD) was diagnosed when cavities, erosion, osteophytes or resorption were seen in the mandibular condyles (Table 1).

This study also describes findings reported in a previous publication (1) (position and shape of the joint disc at T₁, T₃ and T₄ - Table 1) for the same patients enrolled here. The purpose is to make it easier for readers to understand the possible changes in condyle morphology and Helkimo CDI (13).

Clinical exams were carried out to determine the Helkimo CDI at T₁, T₃ and T₄. Clinical functional analysis was performed and the muscles of the stomatognathic system were palpated (24). The analysis of mandibular movements was carried out using a ruler to measure the length of the widest opening and its quality, the extension of border protrusion movements, and left and right laterotrusion. The left and right TMJs were palpated laterally and posteriorly, at rest and during movements. The presence of joint noises or crackling was also checked. The clinical findings were analyzed and scored according to the criteria (13) shown in Table 2. Next, the added score allowed classification

into one of the four levels of dysfunction: 0 points, CDI-0 (Asymptomatic); 1-4 points, CDI-I (Mild); 5-9 points, CDI-II (Moderate); and 10-25 points, CDI-III (Severe). The clinical exams were performed by two examiners experienced in the use of the method ('A' and 'B'), both following the

same protocol. The clinical evaluations in this study were performed twice by examiner "A" (10-day interval) and once by examiner "B" (who also gave the final diagnosis). The second evaluation by examiner "A" was considered final and was compared with the evaluation by examiner

Table 1. Condyle morphology, joint disc position and shape at T₁, T₃ and T₄

Patient	Condyle morphology						Joint disc position											
	Left TMJ			Right TMJ			Left TMJ						Right TMJ					
	T ₁	T ₃	T ₄	T ₁	T ₃	T ₄	T ₁		T ₃		T ₄		T ₁		T ₃		T ₄	
	MC	MC	MC	MC	MC	MC	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO
1	NL	NL	RPCS	NL	NL	RCS	NL	I	NL	I	ADD	DDWR	NL	I	NL	I	AMDD	DDWR
2	NL	NL	NL	NL	NL	NL	NL	I	NL	I	NL	I	NL	I	NL	I	NL	I
3	NL	NL	RPS	NL	NL	RPS	NL	I	NL	I	NL	I	NL	I	NL	I	NL	I
4	NL	NL	RCS	NL	NL	RCS	LDD	I	LDD	I	LDD	I	NL	I	NL	I	NL	I
5	NL	NL	NL	NL	NL	NL	MDD	I	MDD	I	MDD	I	MDD	I	MDD	I	MDD	I
6	NL	NL	NL	NL	NL	NL	NL	I	NL	I	NL	I	NL	I	NL	I	NL	I
7	NL	NL	NL	NL	NL	NL	NL	I	NL	I	NL	I	NL	I	NL	I	NL	I
8	RPS	NL	RPCS	RPS	NL	RPCS	MDD	I	MDD	I	MDD	I	NL	I	NL	I	NL	I
9	NL	NL	RCS	NL	NL	RPCS	NL	I	NL	I	NL	I	NL	I	NL	I	NL	I
10	NL	NL		RPS	RPS		AMDD	DDWR	AMDD	DDWR			AMDD	DDWR	AMDD	DDWR		
11	NL	NL	NL	NL	NL	NL	NL	I	NL	I	ADD	DDWR	ALDD	DDWR	LDD	I	ALDD	DDWR
12	NL	NL		NL	NL		NL	I	NL	I			NL	I	NL	I		
13	RPCS	RPCS		RPS	RCS		ALDD	DDWR	ALDD	DDWR			ADD	DDWR	ADD	DDWR		
14	RPS	RPS	NL	RPS	NL	RPCS	NL	I	NL	I	NL	I	NL	I	NL	I	NL	I
15	RCS	RCS		RPCS	RCS		NL	I	NL	I			NL	I	NL	I		
16	RPS	NL		NL	NL		NL	I	NL	I			NL	I	NL	I		
17	NL	NL		NL	NL		NL	I	NL	I			NL	I	NL	I		
18	NL	RCS	RCS	NL	NL	NL	NL	I	NL	I	NL	I	NL	I	NL	I	NL	I
19	RPCS	RPCS	RPCS	DBD	RPCS	RPCS	ALDD	DDWR	ALDD	DDWR	ALDD	DDWR	ALDD	DDWR	ALDD	DDWR	ALDD	DDWR
20	NL	NL	NL	NL	NL	NL	NL	I	NL	I	NL	I	NL	I	NL	I	NL	I
21	NL	NL	RPCS	RCS	RCS	RCS	ALDD	DDWR	ALDD	DDWR	ALDD	DDWR	NL	I	NL	I	NL	I
22	NL	NL		NL	NL		NL	I	NL	I			NL	I	NL	I		
23	NL	NL	NL	NL	NL	NL	NL	I	NL	I	NL	I	NL	I	NL	I	LDD	I
24	NL	NL		NL	NL		NL	I	NL	I			NL	I	NL	I		
25	NL	NL	NL	NL	NL	NL	MDD	I	MDD	I	MDD	I	MDD	I	MDD	I	MDD	I
26	DBD	DBD	DBD	RCS	RCS	RPCS	ALDD	DDWR	ALDD	DDWR	ALDD	DDWR	AMDD	DDWR	AMDD	DDWR	AMDD	DDWR
27	NL	NL	RCS	NL	NL	NL	AMDD	DDWR	AMDD	DDWR	AMDD	DDWR	AMDD	DDWR	AMDD	DDWR	AMDD	DDWR
28	NL	NL	NL	NL	NL	NL	ADD	DDWR	ADD	DDWR	ADD	DDWR	AMDD	DDWR	AMDD	DDWR	AMDD	DDWR
29	NL	NL	NL	NL	NL	NL	ADD	DDWR	ADD	DDWR	ADD	DDWR	AMDD	DDWR	AMDD	DDWR	AMDD	DDWR
30	NL	NL		NL	NL		NL	I	NL	I			NL	I	NL	I		
31	NL	RPS	RPCS	RPCS	RPCS	RPCS	NL	I	NL	I	NL	I	NL	I	NL	I	NL	I
32	NL	NL	RPS	NL	NL	RPS	NL	I	NL	I	NL	I	NL	I	NL	I	NL	I

MC, Mouth closed; MO, Mouth open; NL, Normal; RPS, Remodeled parasagittal slice; RCS, Remodeled coronal slice; RPCS, Remodeled parasagittal and coronal slice; DBD, Degenerative bone disease; ADD, Anterior disc displacement; AMDD, Anteromedial disc displacement; ALDD, Anterolateral disc displacement; MDD, Medial disc displacement; LDD, Lateral disc displacement; I, Interposed; DDWR, disc displacement with reduction; DDWPR, disc displacement with partial reduction; RP, Retrusive position; Recap, Recaptured; P Recap, Partially recaptured; B, Biconcave; NB, Non-biconcave. Joint disc position and shape. Source: Aidar et al., 2010 (1).

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“B” to assess interexaminer concordance.

Intraobserver and interobserver variability was evaluated. Agreement was poor when kappa was below 0.4, and excellent when greater than 0.75. The nonparametric K and the McNemar tests were used to evaluate concordance

Joint disc shape											
Left TMJ						Right TMJ					
T ₁		T ₃		T ₄		T ₁		T ₃		T ₄	
MC	MO	MC	MO	MC	MO	MC	MO	MC	MO	MC	MO
NB	B	NB	B	NB	B	NB	B	NB	B	NB	B
B	B	B	B	B	B	B	B	B	B	B	B
B	B	B	B	B	B	B	B	B	B	B	B
B	B	B	B	B	B	B	B	B	B	B	B
B	B	B	B	NB	B	B	B	B	B	NB	B
B	B	B	B	B	B	B	B	B	B	B	B
B	B	B	B	B	B	B	B	B	B	B	B
B	B	B	B	B	B	B	B	B	B	B	B
B	B	B	B	B	B	B	B	B	B	B	B
NB	B	NB	N			NB	N	NB	B		
B	B	NB	B								
B	B	B	B			B	B	B	B		
NB	B	NB	NB			NB	B	NB	B		
B	B	B	B	B	B	B	B	B	B	B	B
B	B	B	B			B	B	B	B		
B	B	B	B			B	B	B	B		
B	B	B	B	B	B	B	B	B	B	B	B
NB	NB	NB	B	NB	B	NB	NB	NB	B	NB	B
B	B	B	B	B	B	B	B	B	B	B	B
NB	B	NB	B	NB	B	B	B	B	B	B	B
B	B	B	B			B	B	B	B		
B	B	B	B	B	B	B	B	B	B	B	B
B	B	B	B			B	B	B	B		
B	B	B	B	B	B	B	B	B	B	B	B
NB	B	NB	B	NB	B	NB	NB	NB	B	NB	B
NB	B	NB	B	NB	B	NB	B	NB	B	NB	B
NB	B	NB	B	NB	B	NB	B	NB	B	NB	B
NB	B	NB	B	NB	NB	NB	B	NB	B	NB	NB
B	B	B	B			B	B	B	B		
B	B	B	B	B	B	B	B	B	B	B	B
NB	B	NB	B	NB	B	NB	B	NB	B	NB	B

between left and right TMJs (condyle morphology) and changes due to treatment (condyle morphology and Helkimo CDI). The level of significance was set at 5%. To evaluate independent data at the same observation time (2 x 2 tables: condyle morphology x disc position and condyle morphology x disc shape), a chi-square test was used with Yates's correction for continuity. If the lowest expected frequency was below 5, the Fishers's Exact test was used (2 x 2 tables: CDI categories x diagnosis using MRI of joint disc position) at a 5% level of significance.

Results

Intraobserver variability in the analysis of condyle morphology was K=0.52 for reading 1 vs. 2 and K=0.67 for reading 2 vs. 3. Interobserver kappa (observer A's reading 3 vs. observer B's reading) for condyle morphology (k=0.87) indicated excellent agreement. Intraobserver and interobserver concordance for CDI was also excellent (k=0.94 and k=0.84).

The classifications of condyle morphology with MC and position and shape of the joint disc with MC and MO at T₁, T₃ and T₄ are shown in Table 1.

Comparing left and right TMJ condyle morphology at T₁, a K value of 0.405 (p<0.001) was found, with a 75.1% concordance. It was not possible to calculate Kappa for T₃ and T₄ (concordance of 78.1% and 69.5%). Once substantial agreement was observed, they were pooled.

There was no association between condyle morphology (remodeled and normal) and joint disc position at T₁ (p=0.523), T₃ (p=0.665), T₄ (p=0.526) and shape at T₁ (p=0.771), T₃ (p=0.566), T₄ (p=1.000) or between CDI categories (0 and I) and the MRI diagnosis of joint disc position at T₁ (p=0.057), T₃ (p=0.358) and T₄ (p=1.000).

Condyle Morphology

There were no changes in 55 (86.0%), 28 (60.8%) and 26 (56.5%) TMJs at T₁-T₃ (p=0.326), T₃-T₄ (p<0.05) and T₁-T₄ (p<0.05), respectively. Changes were found in 9 (14.0%), 18 (39.1%) and 20 (43.4%) TMJs at T₁-T₃, T₃-T₄ and T₁-T₄, respectively.

CDI

There were no changes in 26 (86.6%), 16 (76.2%) and 16 (76.2%) patients at T₁-T₃ (p=1.000), T₃-T₄ (p=1.000) and T₁-T₄ (p=1.000), respectively. There were changes in 4 (13.3%), 5 (23.8%) and 5 (23.8%) patients at T₁-T₃, T₃-T₄ and T₁-T₄, respectively.

Discussion

MRI has been shown to be efficient in detecting joint disc disorders and changes in the shape of the fossa, eminence and mandibular condyle (14,15). In this study,

Table 2. Composition of clinical dysfunction index (CDI) at T₁, T₃ and T₄

Patient	Mandibular mobility index (A)				Altered TMJ function (B)				Muscle pain (C)				Joint pain at rest (D)				Joint pain with movement (E)				Sum				CDI							
	T ₁	T ₃	T ₄		T ₁	T ₃	T ₄		T ₁	T ₃	T ₄		T ₁	T ₃	T ₄		T ₁	T ₃	T ₄		T ₁	T ₃	T ₄		T ₁	T ₃	T ₄		T ₁	T ₃	T ₄	
1	1	1	1		1	1	1		1				1				1				1				3	2	2		1	1	1	
2														1				1				1				1	1	0		1	1	0
3					1		1															1				1	0	1		1	0	1
4		1			1	1	1						1					1				1				2	3	1		1	1	1
5					1	1	1						1									1				2	1	0		1	1	0
6		1	1		1	1	1															1				1	2	2		1	1	1
7					1	1	1						5					1				1				7	7	1		11	11	1
8		1			1	1	1											1				1				2	2	0		1	1	0
9					1	1	1															1				1	1	1		1	1	1
10					1	1	1															1				1	1			1	1	1
11					1		1															1				2	0	2		1	0	1
12																										0	0			0	0	0
13	1	1			1	1	1															1				2	3			1	1	1
14						1	1															1				0	1	1		0	1	1
15																										0	0			0	0	0
16																						1				1	1			1	1	1
17						1	1															1				1	1			1	1	1
18					1	1	1															1				2	1	1		1	1	1
19		1			1	1	1															1				2	3	1		1	1	1
20																										0	0	0		0	0	0
21			1		1	1	1															1				2	3	3		1	1	1
22																										0	0			0	0	0

treatment, and it was not known how long those bone changes had been in place. In contrast, the participants in this study experienced condylar flattening over the course of treatment, with nearly all of the changes occurring during phase II. Changes observed could be associated with possible future problems.

In our study, patients with and without changes on MRIs are distributed similarly within the different CDI categories at all time points. This leads to the conclusion that clinical symptoms might be present even when there are no MRI findings. Disc displacement is relatively common in asymptomatic individuals (14), and the clinical diagnosis of no TMD is linked to the high rates of internal derangement detection using MRI (16). In agreement with our findings, a previous study (17) demonstrated that joint noises are not sufficient evidence of dysfunction when there are no other corroborating symptoms, although they may be found in patients with TMJ disc displacement detected using MRI. Joint pain with movement was observed in 18 of 32 patients at T₁ (9 of the 18 patients had disc displacement). There is a low correlation between MRI disc displacement detections and the extent of TMJ pain and dysfunction (18). At T₃, pain disappeared in 10 patients, persisted in 8 and started in 1. At T₄, that number fell to 5 out of 23 patients who already felt pain at T₁ and T₃, with the exception of patient 11, who felt pain at T₁, which disappeared at T₃ and resumed at T₄. Patients 26 and 29 (disc displacement in both joints) were the only ones with joint pain at palpation at rest at T₁, but pain disappeared at T₃ and T₄. Patient 26 had DBD (left condyle), and painful joints are known to be more frequent in the presence of this type of change (15).

The analysis of muscle pain revealed that only patients 1 and 7 had scores 1 and 5 at T₁, with CDI-I and II. For patient 1, muscle pain vanished at T₃, but dysfunction remained at CDI-I. At T₄, although no change occurred in CDI-I, muscle pain resumed in association with disc displacement (left and right TMJs). No changes occurred in patient 7 at T₃; however, at T₄ muscle pain disappeared, and the dysfunction index changed to CDI-I. At T₄, patients 29, 31 and 32 began complaining of muscle pain. Range of movement is the most evident expression of joint function (24), and its limitation may be caused by disc displacement (14). In our study, 13 patients already had disc displacement at T₁, and only patient 13 had limited movements (lower than 7 mm). Patient 1, who had a well-positioned joint disc at T₁, T₃ and T₄ had disc displacement according to both MRIs, a likely sign of dysfunction. Patient 6, the only one not to have a displaced disc at any time during treatment, had limited movements at T₃ and T₄. Our results demonstrated that limited range of movement did not characterize disc displacement in all cases. Limited lateral mandibular

movements may be assigned to restricted movements caused by use of the Herbst appliance (12) and are transient. In our study, at T₃, 6 patients had limited lateral movements and only patient 6 maintained limited movements at T₄; patient 21 started to have this problem at T₄.

Finally, a follow-up evaluation of these patients will be important to elucidate the long-term effects of treatment with Herbst and fixed appliances on the form and function of the TMJ. In conclusion, after phase I, the condyle morphology did not change significantly. At the end of phase II, a mild flattening was seen in some condyles when patients underwent short-term evaluation. In general, no changes occurred in the clinical dysfunction index after the two phases.

Resumo

Este estudo avaliou as mudanças morfológicas nas cabeças da mandíbula das articulações temporomandibulares (ATMs) e calculou o índice de disfunção clínico de Helkimo (IDC) em adolescentes com má oclusão de Classe II Divisão 1 e retrognatismo mandibular, tratados com aparelho de Herbst (fase I) e aparelho ortodôntico fixo (fase II). Trinta e dois adolescentes consecutivos passaram pela fase I e 23 completaram a fase II. As ATMs foram avaliadas qualitativamente por meio de imagem de ressonância magnética (IRM) ao início do tratamento (T₁), durante a fase I (T₂), no final da fase I (T₃) e no final da fase II (T₄). O IDC foi calculado em T₁, T₃ e T₄. De T₁ a T₃ ($p=0,326$) não ocorreram mudanças na morfologia da cabeça da mandíbula em 86,0% das ATMs. De T₃ a T₄ ($p<0,05$) e T₁ a T₄ ($p<0,05$) ocorreram mudanças em 39,1% e 43,4% das cabeças das mandíbulas. Não ocorreram mudanças significantes no IDC de T₁ a T₃, T₃ a T₄ e T₁ a T₄ ($p=1,000$; 86,6%, 76,2% e 76,2% concordância). Após a fase I, não houve praticamente mudanças na morfologia da cabeça da mandíbula. Ao final da fase II, um leve aplainamento foi observado em algumas cabeças das mandíbulas. Pode ser concluído que não ocorreram mudanças significantes no IDC após ambas as fases de tratamento.

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