ORIGINAL ARTICLE

Effects of Herbst appliance treatment on temporomandibular joint disc position and morphology: A prospective magnetic resonance imaging study

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Introduction: The objective of this prospective study was to evaluate changes in the position and morphology of the disc in the temporomandibular joint (TMJ) with magnetic resonance imaging (MRI). **Methods:** The subjects were 32 consecutive adolescent patients with Class II Division 1 malocclusion treated with the Herbst appliance. The MRIs were obtained immediately before treatment (T1), 8 to 10 weeks after appliance placement (T2), and 12 months later (T3). **Results:** Qualitative evaluation of the MRIs showed that, in 42 (65.62%) of the 64 TMJs, the disc was positioned within normal limits at T1. Because of the advancements caused by the Herbst appliance, a tendency for disc retrusion was observed at T2, but at T3 the disc had returned to normal limits. In 22 TMJs (34.37%), the disc was displaced at T1, and no changes were observed at T3. In most subjects, comparison of the morphology of the disc at T1, T2, and, T3 showed no significant change. **Conclusions:** Herbst therapy does not cause adverse effects on the morphology and position of the articular disc in the short term. (Am J Orthod Dentofacial Orthop 2009;136:412-24)

Controversy still persists among orthodontists regarding the relationship between orthodontic treatment and temporomandibular joint (TMJ) disorders (TMD). Some studies[1-5] suggest that orthodontic treatment increases the risk of developing TMD by modifying the balance in the stomatognathic system and altering the relationships of teeth, mandible, and maxilla in the 3 planes of space.[6] On the other hand, longitudinal studies[7-9] and 2 reviews[10,11] concluded that orthodontic treatment neither increased nor diminished the probability of developing TMD at any stage of life. Furthermore, Katzberg et al[12] found no relationship between orthodontic treatment and internal derangement of the TMJ in an evaluation with magnetic resonance imaging (MRI).

In the correction of Class II malocclusion associated with mandibular retrognathism, functional orthopedic appliances have been fundamentally important because they stimulate mandibular growth, which in turn, favors sagittal correction.[13-16]

Furthermore, fixed functional orthopedic appliances (eg, Herbst) produce more consistent condyle and fossae alterations than those with removable functional appliances.[17] Among orthopedic appliances, the Herbst has been much used to maintain the mandible in a constant anterior position, and consequently it does depend on patient cooperation.[18] An additional advantage of the Herbst is that, in patients with partial displacement of the articular disc, the prognosis for repositioning the disc is good.[19]

Studies that evaluated the short- and long-term treatment effects with the Herbst appliance concluded that no deleterious effects on the functional aspect of the TMJ resulted, and no TMD was caused.[19-24] On the other hand, Foucart et al[5] found TMJs with disc displacement after this method of treatment.

Internal TMJ derangement might involve, among other factors, changes in the position and form of the

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articular disc.[25] Changes now can be detected as a result of great advances in diagnostic imagery, especially MRI. This method, which does not use ionizing radiation, obtains high contrast between the tissues and also supplies both anatomic and physiologic data.[26] In studies of cadavers, MRIs have been extremely effective for diagnosis.[27,28]

The objective of this study was to verify possible changes in the position and morphology of the articular disc in the TMJs of adolescents with a retrognathic mandible treated with the Herbst appliance.

Other evaluations of the TMJ will be addressed in future studies.

MATERIAL AND METHODS

Thirty-two white Brazilian adolescents (16 boys, 16 girls) were treated consecutively with Herbst therapy for 12 months. Their mean pretreatment age was 12 years 10 months ± 1 year 2 months (range, 10 years 11 months-15 years 10 months).

These patients had either joints with the disc positioned within standard norms or joints with disc displacement.

Further selection criteria included appliance characteristics, time of appliance use, and type of activation as in a previous study.[24] The patients' initial characteristics are shown in Table I.

The Ethics Research Committee of the Federal University of São Paulo, Brazil, approved this project on June 12, 2002.

The mandibular advancement determined for each patient and reproduced during appliance construction is given in Table II.

In all 32 subjects, the Herbst appliance therapy resulted in Class I or overcorrected Class I dental arch relationships.

The longitudinal evaluation with MRI was the same as in our previous study.[24]

The amount of mouth opening of each patient, used to obtain the MRI, is shown in Table III.

The MRIs were interpreted visually at 3 stages of treatment—immediately before treatment (T1), 8 to 10 weeks after appliance placement (T2), and 12 months later (T3)—by 2 observers (observers A [L.A.A.A.] and B [H.K.Y.]) who received previous training in using the same protocol.

The protocol had 2 parts: evaluation of the anatomic position of the disc with the mouth closed (MC) and the mouth open (MO), and evaluation of the morphology of the disc with the MC and the MO.

The anatomic disc position with the MC was classified according to Tasaki et al[29] (adapted): (1) superior disc position (normal), posterior band of disc superior to condyle, in a relationship from 11 o'clock to 1 o'clock; (2) anterior disc displacement (ADD); (3) partial anterior disc displacement in the lateral third of the joint; (4) partial anterior disc displacement in the medial third of the joint; (5) anterolateral disc displacement (ALDD); (6) anteromedial disc displacement (AMDD); (7) lateral disc displacement (LDD), disc displaced laterally to the lateral pole of the condyle; (8) medial disc displacement (MDD), disc displaced medially to the medial pole of condyle; (9) posterior disc displacement, with the disc displaced posterior to the 1 o'clock position on top of the condyle or a position assumed by the articular disc in relation to the condyle when the mandible was advanced with the Herbst appliance (retrusive position [RP]); (10) recaptured (Recap) was noted when a displaced disc in the MC position at

Table I. Characteristics of the patients at T1

Patient	*Sex*	*Age at T1 (y/mo)*	*Class II molar relationship*		*Overjet (mm)*	*Björk and Helm[75] stages hand-wrist x-rays*
			Right side	*Left side*		
1	Female	11/11	¾	½	7	S
2	Female	12/11	¾	½	6	MP_3cap
3	Male	14/6	*	*	9	MP_3cap
4	Female	12/5	*	*	9.5	MP_3cap
5	Female	11/9	¾	*	10	S
6	Female	11/2	¾	*	11	S
7	Female	11/0	*	¾	13	S
8	Male	14/2	¾	½	6	MP_3cap
9	Male	12/9	*	*	8	S
10	Female	11/5	¾	¾	12	MP_3cap
11	Female	11/9	¾	*	7	MP_3cap
12	Female	11/11	¾	¾	12	MP_3cap
13	Female	13/9	¾	½	12	MP_3cap
14	Male	13/9	¾	¾	7	MP_3cap
15	Male	12/4	*	½	11	S
16	Female	13/4	¾	¾	9	MP_3cap
17	Male	14/2	¾	*	10	S
18	Male	11/9	*	½	7	MP_3cap
19	Male	13/8	½	½	7	MP_3cap
20	Male	13/2	¾	¾	7	S
21	Female	12/4	½	½	6	MP_3cap
22	Female	12/2	½	¾	9	MP_3cap
23	Male	13/0	¾	½	8	MP_3cap
24	Female	12/5	*	*	8	MP_3cap
25	Female	11/6	½	½	6	MP_3cap
26	Male	13/9	*	*	11	MP_3cap
27	Male	13/9	*	¾	8	S
28	Male	14/0	½	*	7	MP_3cap
29	Male	13/2	½	¾	10	S
30	Male	13/10	½	½	5	MP_3cap
31	Male	15/10	¾	*	9	MP_3cap
32	Female	12/0	*	¾	8	S

*Full Class II; *S,* Björk and Helm[75] third stage; *MP_3cap,* Björk and Helm[75] fourth stage.

Table II. Mandibular advancement (mm)

	T1		After 3 months	
Patient	Right	Left	Right	Left
1	4	4	2	2
2	4	3	2	2
3	6	5	3	3
4	6	6	3	3
5	3	5	2	3
6	4	6	3	3
7	6	6	3	3
8	5	5	0	0
9	6	6	3	3
10	6	6	2	2
11	5	5	2	2
12	6	6	2	2
13	4	4	2	2
14	6	6	2	2
15	5	5	2	2
16	6	6	0	0
17	3	5	3	3
18	6	3	2	0
19	4	4	2	2
20	5	5	2	2
21	4	4	0	0
22	6	6	0	0
23	6	3	2	3
24	3	5	3	3
25	5	5	0	0
26	4	4	3	3
27	6	6	3	3
28	4	4	2	2
29	6	6	0	0
30	5	5	0	0
31	6	6	2	2
32	6	6	3	3

Table III. Buccal openings (in mm) preestablished clinically for each patient to acquire MRIs with MO

Patient	Buccal opening
1	34
2	30
3	34
4	32
5	30
6	32
7	36
8	28
9	38
10	37
11	35
12	32
13	31
14	35
15	34
16	31
17	39
18	31
19	40
20	45
21	36
22	34
23	36
24	36
25	32
26	39
27	34
28	34
29	32
30	34
31	32
32	31

T1 was recaptured at T2 because of the mandibular advancement from the Herbst appliance; (11) partially recap (P Recap) was noted when a displaced disc in the MC position at T1 was partially recaptured at T2 because of the mandibular advancement from the Herbst appliance; and (12) indeterminate, with no clear image of the disc, preventing classification into any of the above categories.

The functional disc position with the MO was classified according to Tasaki et al[29] (adapted): (1) interposed was noted when a disc in the MO position maintained a position between the condyle and the articular eminence in all sections; (2) disc displacement with reduction (DDWR) was noted when a displaced disc in the MC position assumed a position between the condyle and the articular eminence in the MO position; (3) disc displacement with no reduction (DDWNR) was noted when a displaced disc in the MC position did not achieve a position between the condyle and the articular eminence in the MO position; (4) disc displacement with partial reduction (DDWPR) was noted when a displaced disc in the MC position returned partially to its position between the condyle and the articular eminence in the MO position; and (5) indeterminate was noted when the disc could not be identified.

Images taken in the coronal plane were used to prevent false negative findings during the displacement of the disc in a mediolateral direction (Fig 1). In these images, the position of the articular disc was classified as superior (normal) when it appeared to be located in the central portion of the mandibular condyle. A medial or lateral classification was determined when the disc was diagnosed in a medial or lateral pole of the condyle, as seen in a parasagittal plane tangent to the center of the condyle.[30-32]

The morphology of the disc was analyzed and classified with MC and MO in the parasagittal images at T1, T2, and T3.

The disc was classified according to Ribeiro[32] as biconcave (normal morphology) or not biconcave

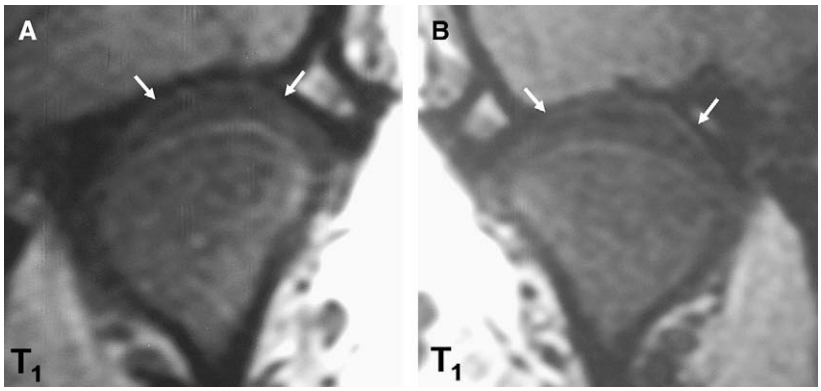

Fig 1. Patient 20, TMJ MRIs: **A,** left, and **B,** right. The coronal plane was used to locate articular disc position in the mediolateral direction.

when there was an increase or a deformity of the bands of the disc.

All MRIs were analyzed by 2 observers with MRI protocol after they were calibrated for 4 months.[33] Images for this study were then interpreted 3 times, with a double-blind procedure,[34] by observer A and once by observer B (who also gave the final diagnosis). Observer A's interpretations, at regular 15-day intervals, were divided into preliminary and final readings. The preliminary readings consisted of 1 interpretation before observer A received training (pretraining) and 1 after training (posttraining). 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.

Statistical methods

Intraobserver and interobserver variability in reporting MRIs of the TMJ was evaluated with kappa statistics and 95% confidence intervals as described by Fleiss.[35] A kappa value of less than 0.4 was considered poor, and a value greater than 0.75 was considered excellent.

RESULTS

The assessment of intraobserver variability showed that pretraining and posttraining readings (reading 1 vs reading 2) and posttraining and final readings (reading 2 vs reading 3) were correlated, and the kappa values were low for the evaluation of articular disc morphology (reading 1 vs 2 [kappa = 0.39)] and reading 2 vs 3 [kappa = 0.49]). The evaluation of articular disc position gave excellent results: kappa >0.75 for readings 1 vs 2 and readings 2 vs 3, with kappa = 0.79 and kappa = 0.95, respectively. Interobserver agreement (observer A's reading 3 vs observer B's reading) concerning disc morpholgy (kappa = 0.75) and position (kappa = 0.93) was good.

In a visual evaluation of the MRIs at T1 with the MC, the disc was in a superior position (normal) in 42 TMJs (patients 1-3, 6, 7, 9, 12, 14-18, 20, 22-24, and 30-32, right and left TMJs; patients 4, 8, and 21, right TMJs; and patient 11, left TMJ).

At T2, because of the mandibular advancement from the Herbst appliance, the disc had a tendency to assume a more retrusive position in relation to the condyle.

At T3, the disc had returned to the superior position (Fig 2).

In the MO position, the articular disc was interposed between the mandibular condyle and the articular eminence in 42 TMJs at T1, T2, and T3 (Fig 3).

In 7 TMJs (patients 10 and 27, right and left TMJs; patients 26, 28, and 29, right TMJ) in the MC position, there was AMDD at T1 (Fig 4). At T2, there were Recap (patients 10 and 27, right and left TMJs; patient 29, right TMJ) and P Recap (patients 26 and 28, right TMJ) of the articular disc from the mandibular advancement of Herbst therapy. At T3, the disc had returned to its original position. With the MO (patient 26, right TMJ), there was DDWPR at T1 and T3. At T2, there was DDWR. In the remaining articulations, there was DDWR at T1, T2, and T3.

In 6 TMJs (patient 11, right TMJ; patients 13, 21, and 26, left TMJ; patient 19, right and left TMJs) in the MC position, there was ALDD at T1. At T2, there was Recap of the articular disc after the mandibular advancement of Herbst therapy. At T3, the disc had returned to its original position, with the exception of 1 articulation (patient 11, right TMJ) that still had LDD. With the MO, there was DDWR in 3 TMJs (patients 13, 21, and 26, left TMJ) at T1, T2, and T3. In patient 11 (right TMJ), there was DDWR at T1 and

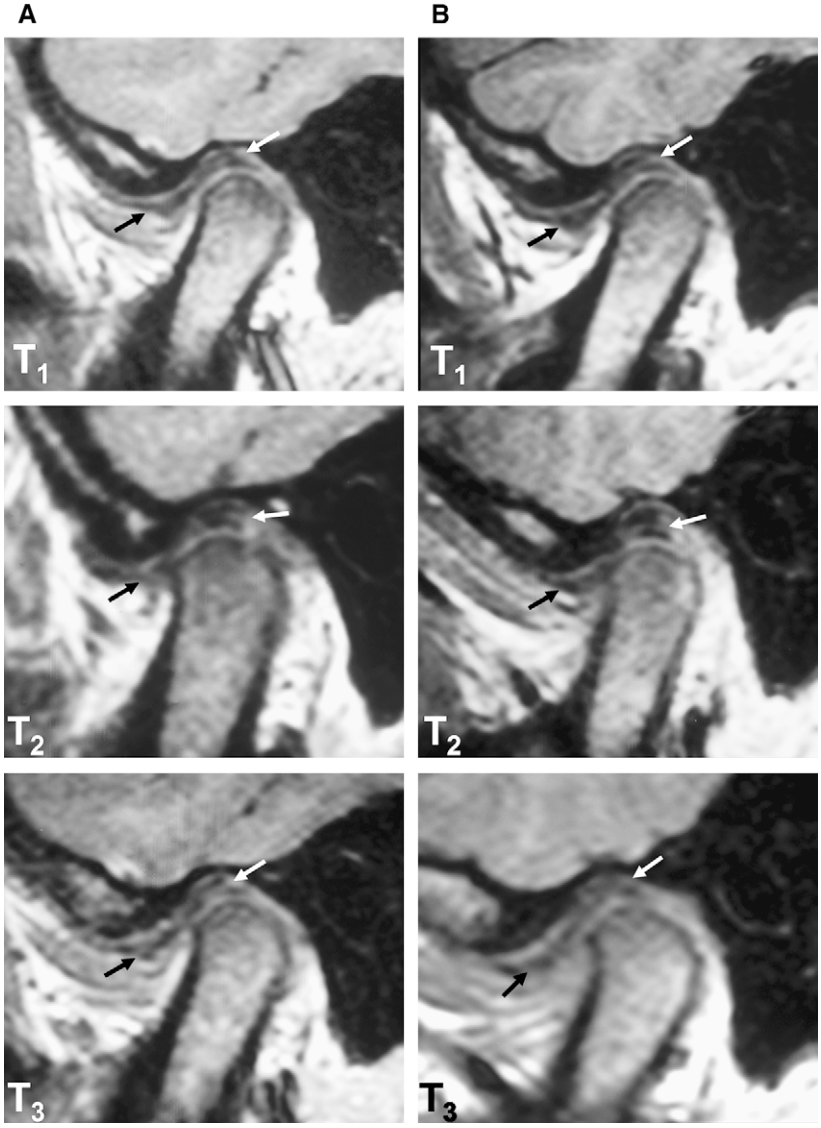

Fig 2. Patient 20, TMJs MRIs with MC: **A,** left, and **B,** right. The articular disc is in its normal superior position at T1 and T3 but shows a retrusive tendency at T2. Disc morphology is biconcave at T1, T2, and T3.

T2, and the disc was interposed at T3. In patient 19 (right and left TMJs), there was DDWPR at T1 and DDWR at T2 and T3.

In 5 TMJs (patients 5 and 25, right and left TMJs; patient 8, left TMJ) in the MC position, MDD was observed at T1. At T2, after mandibular advancement produced by the Herbst appliance, the disc had a tendency to assume a more retrusive position in relation to the condyle. At T3, the disc reassumed its original position in the TMJs evaluated. In the MO position, the articular disc was interposed between the mandibular condyle and the articular eminence at T1, T2, and T3.

In 3 TMJs (patient 13, right TMJ; patients 28 and 29, left TMJ) in the MC position, there was ADD at T1. At T2, there were 1 P Recap (patient 13, right TMJ) and 2 Recaps (patients 28 and 29, left TMJ) of the articular disc from the mandibular advancement of Herbst therapy. At T3, the disc had returned to its original position. With the MO, there was DDWR in 3 TMJs at T1, T2, and T3.

In 1 TMJ (patient 4, left TMJ) in the MC position, LDD was observed at T1. At T2, after mandibular advancement from the Herbst appliance, the disc had a tendency to assume a more RP in relation to the condyle. At

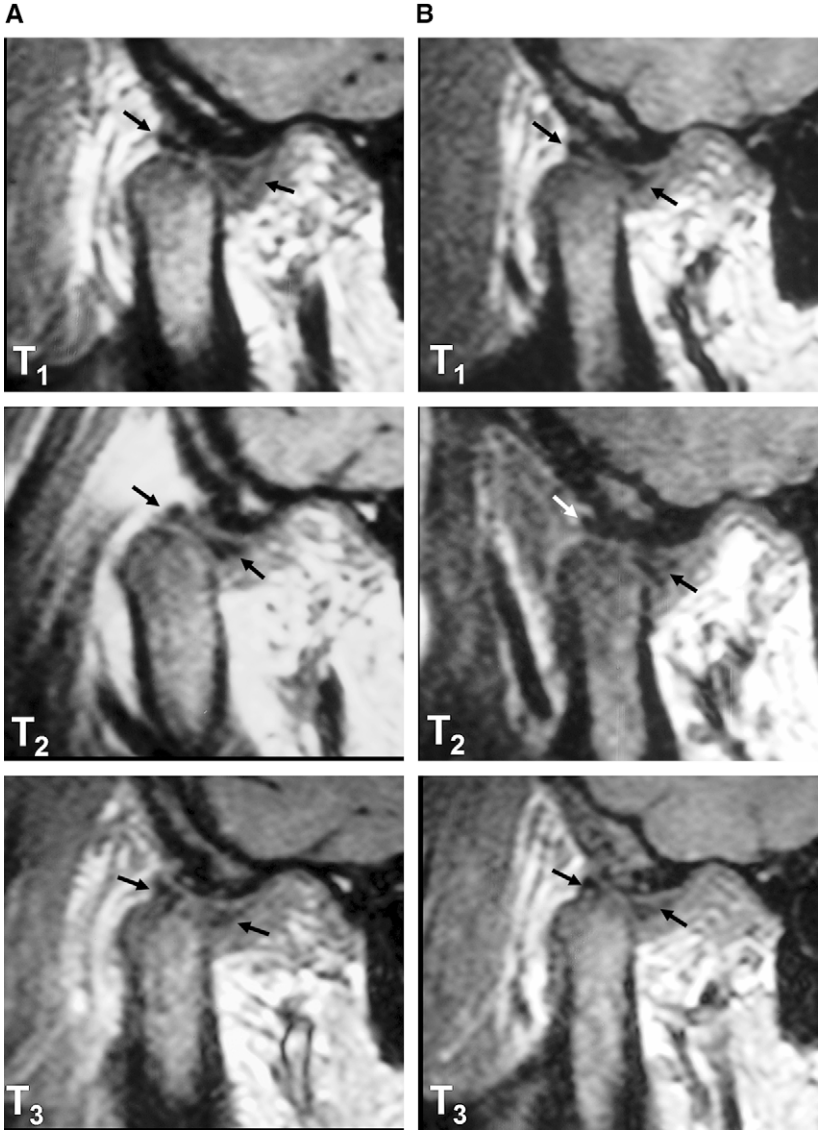

Fig 3. Patient 20, TMJ MRIs with MO: **A,** left, and **B,** right. The articular disc was interposed between the mandibular condyle and the articular eminence at T1, T2, and T3. Disc morphology is biconcave at T1, T2, and T3.

T3, the disc reassumed its original position in the TMJ evaluated. In the MO position, the articular disc was interposed between the mandibular condyle and the articular eminence at T1, T2, and T3 (Table IV).

In 43 joints (patients 2-9, 12, 14-18, 20, 22-25, 30, and 31, right and left TMJs; patient 21, right TMJ), the disc had biconcave morphology with the MC and MO at T1, T2, and T3 (Figs 2 and 3).

In 11 joints (patients 1, 29, and 32, right and left TMJs; patient 11, right TMJ; patients 13, 21, 26, and 28, left TMJs), the disc had not-biconcave morphology with the MC and biconcave with the MO at T1 and T3. At T2, the disc was biconcave with the MC and MO.

In 6 joints (patients 10 and 27, right and left TMJs; patients 13 and 28, right TMJs), the disc had not-biconcave morphology with the MC and biconcave with the MO at T1, T2, and T3.

In 2 joints (patient 19) the disc had not-biconcave morphology with the MC and MO at T1. At T2, the disc was biconcave with the MC and MO. At T3, the disc was not biconcave with the MC; however, the discs of both joints were biconcave with the MO.

In 1 joint (patient 26, right TMJ), the disc was not biconcave with the MC and MO at T1. At T2 and T3, the disc was not biconcave with the MC and biconcave with the MO.

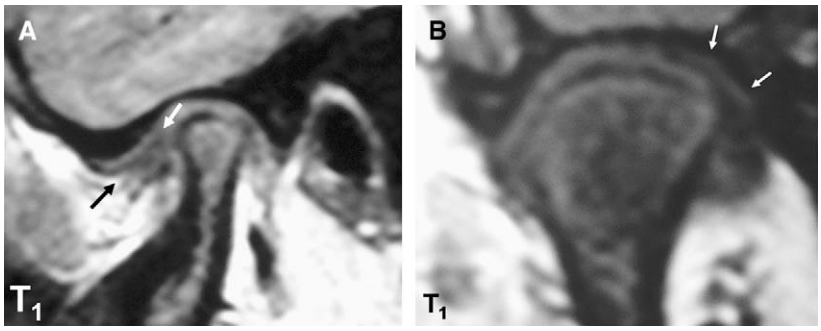

Fig 4. Patient 10, right TMJ MRIs with MC: **A,** parasagittal and **B,** oblique coronal plane. There is AMDD at T1. Disc morphology is not biconcave at T1.

In 1 joint (patient 11, left TMJ), the disc was biconcave with the MC and MO at T1 and T2. At T3, the disc was not biconcave with the MC and biconcave with the MO (Table V).

DISCUSSION

MRI has high sensibility for visualization of the position and configuration of the disc.[26,36] Recent studies have shown that we can have greater confidence in MRI as a diagnostic tool because of the improved quality obtained from devices at 1.5 T.[28]

In this study, the MRIs were obtained in the parasagittal and oblique coronal planes, which are complementary and follow the medial angulations of the condyles. The purpose was to better visualize the posterior band of the disc.[37] In addition, confidence in diagnosis is increased when one considers the parasagittal and coronal images together.[38]

The normal position of the posterior band of the disc is described as at 12 o'clock in relation to the condyle in the MC position.[26,28,29,31,39] On the other hand, other studies showed variations in the position of the disc in asymptomatic subjects.[29,39-42] Different metric procedures for analyzing sagittal disc position have been proposed because the 12-o'clock method for determining disc position relative to the condylar head has led to misinterpretation. However, there is consensus that normal variations occur in physiologic positions, and disc position might be described differently depending on the reference lines used.[22,43] In our study, the posterior band of the disc was classified as in a normal position when it was between 11 o'clock and 1 o'clock; this allowed for physiologic variations.[19]

The results showed that, at T1 in the MC position, the disc was in a superior position (normal) in 42 joints (65.62%). At T2, because of the mandibular advancement from the Herbst appliance, on average, the disc had a tendency toward an RP in relation to the condyle. At T3, the disc returned to the superior position. Our findings agreed with previous investigations.[19,22]

On the other hand, our results were contrary to those Foucart et al,[5] who reported that 3 of 10 previously healthy patients who used the Herbst appliance developed disc displacement after treatment. Those authors evaluated results from removable appliances, rather than those from a fixed Herbst appliance as in our study. They also used sagittal MRI and not our angulated sagittal images (parasagittal).

Other studies that evaluated the position of the articular disc with MRI but used other types of functional orthopedic appliances found no adverse effects in disc position; this agrees with our findings.[43-45]

Some investigators who used quantitative evaluations to discern the effects of the Herbst appliance found that, on average, the disc returned to its original pretreatment position, although a mild RP of the disc prevailed.[19,22,24] It was suggested that this might be caused by the change in form from condyle and fossa remodeling.[19] Also, remodeling of the disc during the bite jump could have contributed to its retrusion[46,47]; however, the capacity for remodeling is limited by the lack of vascularization.[48] If this is the case, the frequent tendency for disc retrusion after Herbst appliance therapy could be considered a therapeutic measure in patients with ADD.[22]

However, studies that evaluated removable functional orthopedic appliances—eg, Twin-block and activator—did not corroborate this hypothesis; rather, they showed that these appliances were incapable of recapturing the disc independently of its displacement.[43,49] Studies that evaluated disc-repositioning therapies with MRI showed that disc recapture is achievable only when the condyle was permanently displaced anteriorly.[50-52]

In this study, MRIs evaluated with the MC showed that, in 22 of 64 joints (34.37%), the articular disc was displaced at T1 (1 LDD, 3 ADD, 5 MDD, 6 ALDD,

Table IV. Articular disc position at T1, T2, and T3

	T1				*T2*				*T3*			
	Left TMJ		*Right TMJ*		*Left TMJ*		*Right TMJ*		*Left TMJ*		*Right TMJ*	
Patient	*MC*	*MO*	*MC*	*MO*	*MC*	*MO*	*MC*	*MO*	*MC*	*MO*	*MC*	*MO*
1	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
2	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
3	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
4	LDD	I	NL	I	RP	I	RP	I	LDD	I	NL	I
5	MDD	I	MDD	I	RP	I	RP	I	MDD	I	MDD	I
6	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
7	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
8	MDD	I	NL	I	RP	I	RP	I	MDD	I	NL	I
9	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
10	AMDD	DDWR	AMDD	DDWR	Recap	DDWR	Recap	DDWR	AMDD	DDWR	AMDD	DDWR
11	NL	I	ALDD	DDWR	RP	I	Recap	DDWR	NL	I	LDD	I
12	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
13	ALDD	DDWR	ADD	DDWR	Recap	DDWR	P Recap	DDWR	ALDD	DDWR	ADD	DDWR
14	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
15	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
16	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
17	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
18	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
19	ALDD	DDWPR	ALDD	DDWPR	Recap	DDWR	Recap	DDWR	ALDD	DDWR	ALDD	DDWR
20	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
21	ALDD	DDWR	NL	I	Recap	DDWR	RP	I	ALDD	DDWR	NL	I
22	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
23	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
24	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
25	MDD	I	MDD	I	RP	I	RP	I	MDD	I	MDD	I
26	ALDD	DDWR	AMDD	DDWPR	Recap	DDWR	P Recap	DDWR	ALDD	DDWR	AMDD	DDWPR
27	AMDD	DDWR	AMDD	DDWR	Recap	DDWR	Recap	DDWR	AMDD	DDWR	AMDD	DDWR
28	ADD	DDWR	AMDD	DDWR	Recap	DDWR	P Recap	DDWR	ADD	DDWR	AMDD	DDWR
29	ADD	DDWR	AMDD	DDWR	Recap	DDWR	Recap	DDWR	ADD	DDWR	AMDD	DDWR
30	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
31	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I
32	NL	I	NL	I	RP	I	RP	I	NL	I	NL	I

MC, mouth closed; *MO*, mouth open; *NL*, normal; *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.

and 7 AMDD). The greater prevalence of the medial component in the displacement of the disc agrees with other investigations.[30,53-55] On the other hand, in contrast to our findings, Tasaki et al[29] found a high prevalence of ALDD in patients and asymptomatic volunteers. Ruf and Pancherz[19] also found, at the beginning of Herbst therapy, that 5 of 22 joints had varying degrees of ADD associated with a transverse displacement component.

In our study at T2, there were instances of Recap (patients 10, 19, 27, and 29, left and right TMJs; patient 11, right TMJ; patients 13, 21, 26, and 28, left TMJs) and P Recap of the discs (patients 13, 26, and 28, right TMJs) facilitated by the mandibular advancement from the Herbst appliance. However, at T3, the disc had returned to its original position. In patient 11 (right TMJ), although the disc continued to be displaced at T3, it changed from ALDD at T1 to LDD at T3. The stability of this change is dubious.

These results agree with those already described in the literature affirming that, in the case of total DDWR, only temporary repositioning of the disc can be obtained with Herbst treatment.[19] The retrusive effect of the Herbst appliance over the position of the disc observed at T2 appears insufficient to stabilize it. Consequently, in agreement with previous studies, the disc returned to the displaced position when the condyle moved backward in the fossa during the posttreatment period.[52,56,57] The degree of displacement and the absence of transverse displacement (lateral or medial) could be favorable to the success of stability of the disc position at T3.[52,58]

Table V. Articular disc morphology at T1, T2, and T3

	T1				*T2*				*T3*			
	Left TMJ		*Right TMJ*		*Left TMJ*		*Right TMJ*		*Left TMJ*		*Right TMJ*	
Patient	*MC*	*MO*	*MC*	*MO*	*MC*	*MO*	*MC*	*MO*	*MC*	*MO*	*MC*	*MO*
1	NB	B	NB	B	B	B	B	B	NB	B	NB	B
2	B	B	B	B	B	B	B	B	B	B	B	B
3	B	B	B	B	B	B	B	B	B	B	B	B
4	B	B	B	B	B	B	B	B	B	B	B	B
5	B	B	B	B	B	B	B	B	B	B	B	B
6	B	B	B	B	B	B	B	B	B	B	B	B
7	B	B	B	B	B	B	B	B	B	B	B	B
8	B	B	B	B	B	B	B	B	B	B	B	B
9	B	B	B	B	B	B	B	B	B	B	B	B
10	NB	B	NB	B	NB	B	NB	B	NB	B	NB	B
11	B	B	NB	B	B	B	B	B	NB	B	NB	B
12	B	B	B	B	B	B	B	B	B	B	B	B
13	NB	B	NB	B	B	B	NB	B	NB	B	NB	B
14	B	B	B	B	B	B	B	B	B	B	B	B
15	B	B	B	B	B	B	B	B	B	B	B	B
16	B	B	B	B	B	B	B	B	B	B	B	B
17	B	B	B	B	B	B	B	B	B	B	B	B
18	B	B	B	B	B	B	B	B	B	B	B	B
19	NB	NB	NB	NB	B	B	B	B	NB	B	NB	B
20	B	B	B	B	B	B	B	B	B	B	B	B
21	NB	B	B	B	B	B	B	B	NB	B	B	B
22	B	B	B	B	B	B	B	B	B	B	B	B
23	B	B	B	B	B	B	B	B	B	B	B	B
24	B	B	B	B	B	B	B	B	B	B	B	B
25	B	B	B	B	B	B	B	B	B	B	B	B
26	NB	B	NB	NB	B	B	NB	B	NB	B	NB	B
27	NB	B	NB	B	NB	B	NB	B	NB	B	NB	B
28	NB	B	NB	B	B	B	NB	B	NB	B	NB	B
29	NB	B	NB	B	B	B	B	B	NB	B	NB	B
30	B	B	B	B	B	B	B	B	B	B	B	B
31	B	B	B	B	B	B	B	B	B	B	B	B
32	NB	B	NB	B	B	B	B	B	NB	B	NB	B

MC, Mouth closed; *MO,* mouth open; *B,* biconcave; *NB,* not biconcave.

On the other hand, Ruf and Pancherz[19] found, in 3 of 6 joints with DDWR at the beginning of treatment, that the disc was positioned normally after Herbst therapy; this does not match our findings.

In our study, where the maximum mandibular advancement was 6 mm at T1, the necessary advancement for possible articular disc recapture was not considered. However, in all joints with disc displacement at T1 evaluated with the MC, there was total or partial disc recapture at T2. Complementary advances of the mandible took place in most patients after 3 months of treatment, but the articular disc did not remain stable in any patient at T3.

In contrast to our study, previous investigations with the Herbst appliance recommended edge-to-edge mandibular advancement in the incisal region, without considering the initial overjet.[19,22,59,60] On 1 hand, progressive advances result in the condyles leaving the glenoid fossae to a lesser extent and consequently cause less disc retrusion, whereas, on the other hand, they favor greater skeletal effects, principally in the glenoid fossa[61] and thus promote Class II correction.[62]

One could speculate that greater mandible advancement at the beginning of treatment could cause greater joint stress because the disc would assume a more RP, and, over a long period, there could be future consequences for TMJ health. However, in TMJs with DDWPR at T1, such greater advancements would act favorably because they locate the articular disc in a more RP in relation to the condyle, and, consequently, the possibility of obtaining stability would be greater after treatment.

Another aspect to be considered is treatment time with the Herbst appliance. In our study, it was 12 months,

which contrasted with other studies that recommended on average 7 months.[19,22,59,60] If it could be speculated that longer treatment time could help the return of the condyle to the glenoid fossa, then it appears not to have been decisive in this study to stabilize the disc position in joints in subjects with disc displacement at T1.

The prognosis for repositioning the disc depends on its degree of displacement at pretreatment. A disc with partial displacement can be repositioned successfully and remain stable until the final observation.[19] However, rotational disc displacement (anterolateral or anteromedial) has been shown to interfere with the prognosis of disc recapture.[52,58]

Other factors such as condyle morphology, articular fossa, and articular tubercule interfere with the biomechanism of the TMJs. Evidence from autopsy studies suggests that the anatomic forms of the condyles and fossae can predispose to disc displacement, and an excessively large eminence can also be etiologic factors in disc displacement.[63,64]

In our study, when considering the total evaluation period (T1-T3), joints that had DDWR at T1 did not progress to DDWNR at T3. One patient (19) had DDWPR (right and left TMJs) at T1 and DDWR in both joints at T2 and T3. In contrast with our findings, Ruf and Pancherz[19] found that 3 of 6 joints with DDWR at the beginning of treatment evolved into DDWNR at the end of treatment. Disc displacement progression has been reported in some patients, but the causes are unknown.[65] The development of a pseudodisc, because of the extensive fibrotic adaptation of the posterior ligament is another outcome that is often mentioned with regard to these joints.[66,67]

In our study, in agreement with other results in the MO position in most patients, the disc was found to be interposed between the condyle and the articular tubercule at T1, T2, and T3.[22,23]

In addition to the position of the disc, alterations in disc morphology are involved in internal derangements of the TMJs.[25] During movement of the mandible, the disc is flexible to a certain extent and can adapt to the functional demands of the articular surfaces.[68] However, flexibility and adaptability do not mean that the morphology of the disc will always be reversibly altered during function.

The mechanism by which the disc translates with the condyle depends on its morphology and interarticular pressure. Thus, disc morphology is extremely important for maintaining the appropriate position during function.[69]

Vargas-Pereira,[41] evaluating articular disc morphology quantitatively with MRI and comparing the results with data from histologic[70] and microanatomic[71] studies, found that the anterior band was slightly increased, but the intermediate zone and the posterior band maintained the same initial dimension. Based on this observation, the author stressed that the values from MRI are extremely accurate, and therefore the conclusions drawn about disc morphology are valid. If this is true, there might be alterations to disc form during Herbst treatment because of the compression of the condyle and the articular disc against the articular eminence.[72] This compression has been associated with reduction of condylar growth, TMD, and osteoarthritic changes, including degenerative condylar flattening in a few preadolescents treated with the Herbst appliance.[21,73]

In this study, no alterations to disc morphology occurred in 60 TMJs (93.75%) from T1 through T3. In 3 joints (4.68%; patient 19, right and left TMJs; patient 26, right TMJ) at T3, disc morphology improved with the MO, but remained displaced with the MC. From T1 through T3, Herbst therapy improved disc morphology in 3 joints.

In 1 joint (1.56%; patient 11, left TMJ), disc morphology worsened at T3 with the MC. In this case, alteration of disc morphology with disc displacement in the right TMJ could increase the frequency in up to 60% of disc displacements in the left joint.[74] Perhaps only with longitudinal monitoring of this patient will it be possible to evaluate the truth of this statement.

In the study of Franco et al,[33] using a Fränkel II functional regulator, disc morphology in the control group remained unaltered; however, there was significant improvement in the treated subjects. Our findings are similar to those results, even though different methodologies were used.

Based on our results with reference to the behavior of disc position and form, we suggest that comparative studies should be developed to verify whether greater mandible advances or different designs of the Herbst appliance could aid in the reduction of the displaced discs.

We believe that continuation of this investigation, which would involve studying the patients longitudinally and analyzing the repercussions of disc displacement with clinical evaluations of function and symptoms, and a larger sample size would contribute to a clearer understanding of the effects of orthodontic-orthopedic treatment of the TMJ.

CONCLUSIONS

Based on our results, we can conclude the following during the 12 months of treatment with the Herbst appliance.

1. There were no adverse changes in the position of the articular disc at T3 in adolescents whose discs were within normal limits at T1.
2. The disc was not recaptured at T3 in the TMJs with disc displacement at T1.
3. There were no adverse changes in articular disc morphology.

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