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The changes in temporomandibular joint disc position and configuration in early orthognathic treatment: a magnetic resonance imaging evaluation

Hatice Gökalp*, Mirzen Arat* and Ilhan Erden**
Departments of *Orthodontics and **Radiology, School of Medicine, Ankara University, Turkey

SUMMARY This study aimed to examine the effects of chin cup therapy on the temporomandibular joint (TMJ) disc position and configuration with magnetic resonance imaging (MRI).

Twenty-five individuals ranging in age from 5 to 11 years were evaluated. The treatment group consisted of 15 subjects (10 females and five males) with prognathic facial structures, while the control group comprised 10 subjects (six females and four males) with an orthognathic facial structure. The magnitude of the chin cup force applied to the mandible was 600 g. Unilateral MRIs of the TMJ were taken in all subjects at the beginning and end of the study.

No statistically significant changes in the TMJ disc position and configuration during the treatment and control periods could be seen. The values of the alpha angle measurements were found to be different in the treatment and control groups at the beginning (166.23 ± 2.15 and 172 ± 1.97, respectively), and end of the treatment and control periods (160.00 ± 2.16 and 172.00 ± 2.68).

These findings show that if the chin cup appliance is used at an early age and with appropriate forces, there will be no adverse effect on the TMJ disc position and configuration.

Introduction

In the early treatment of skeletal Class III, the chin cup has been used for many years with the aim of establishing a more normal anteroposterior jaw relationship (Janzen and Bluher, 1965; Joho, 1973; Wendell and Nanda, 1985; Ritucci and Nanda, 1986; Sugawara *et al*., 1990).

It is claimed that chin cup treatment, in which backward force is applied to the mandibular condyle, may lead to internal derangement of the TMJ (Wyatt, 1987; Tanne *et al*., 1996).

However, orthodontic treatment is known to result in a more stable dentoskeletal structure and to eliminate any symptoms of TMJ dysfunction which might have existed prior to treatment (Dibbets and van der Weele, 1987; Witzig and Spahl, 1991; Katzberg *et al*., 1996).

There are many factors leading to internal derangement of TMJ. The disc position has been found to change relative to the mandibular condyle, fossa, and articular eminence.

This study examined the changes resulting from the chin cup treatment in the TMJ disc position and configuration with MRI.

Subjects and methods

This study was carried out on two groups of subjects with orthognathic and prognathic facial types. The treatment group consisted of 15 subjects (10 females and five males) with a prognathic facial type, whose skeletal age ranged from 5 to 11 years. The control group was made up 10 subjects (six females and four males) with

orthognathic profiles, whose skeletal age ranged from 8 to 10 years. The subjects comprising the control group received no treatment whereas those in the treatment group underwent treatment with a chin cup. The chin cup force was applied in a condyle–chin direction. The magnitude of the applied chin cup force was in total 600 g. The patients agreed to wear the chin cup for at least 16 hours a day.

All the individuals were clinically examined and only those with no clinical symptoms of a TMJ disorder were included in the study. At the beginning of the study, unilateral MRIs of the TMJ area of all the subjects were obtained in the closed mouth position in the oblique sagittal plane. The subjects included in the study were between 5 and 11 years of age. Their MRIs were taken in a closed MR machine. It took 7 minutes to obtain a unilateral MRI of the joint by means of a closed MRI machine. It would have taken approximately 15 minutes to obtain a bilateral MRI of the joint. Thus, as it was considered that the subjects would be unable to tolerate this length of time in the MR machine, unilateral MRIs were preferred, because the children who were not able to tolerate the MRI scans were subsequently excluded from the study, resulting in a limited number of subjects.

The subjects were made to lie in a supine position, and the head was stabilized with a

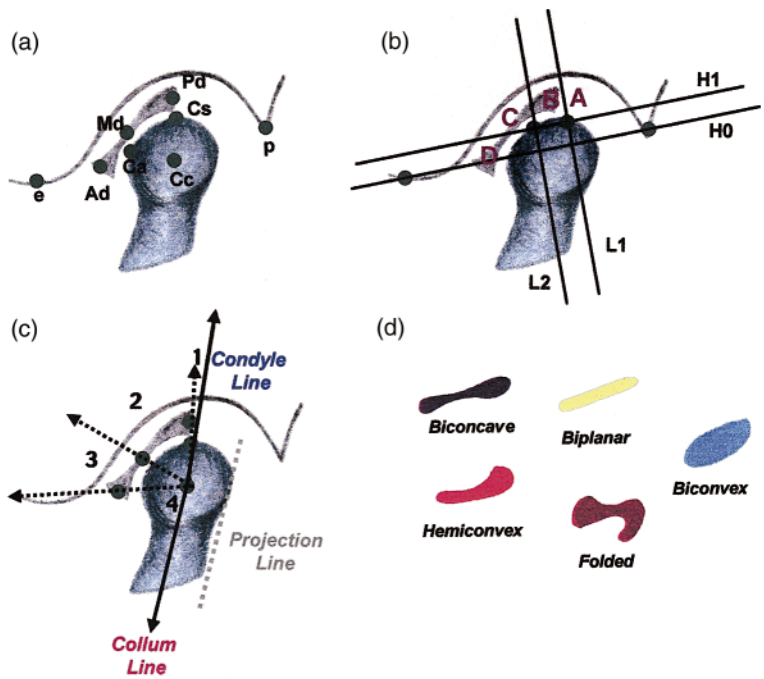

Figure 1 (a) The reference points determined on MRIs. e, Articular eminence; p, post-glenoid process; Ad, the middle of anterior disc band; Md, the middle of intermediate region of disc; Pd, the middle of posterior disc band; Ca, anterior edge of functional surface of condyle; Cs, superior edge of functional surface of condyle; Cc, centre of condyle. (b) Criteria for disc position on MRIs. H1: line parallel to H0 passing the anterior edge of functional surface of the condyle. H0: line tangent from the points e and p. L1: Line perpendicular to H0 passing through point Cs. L2: line perpendicular to H0 passing through point Ca. The disc position was classified according to whether the posterior band was in compartment A, B, C or D in the closed-mouth position. A, the 12 o'clock position was considered to be normal. B or C, are either normal, partial anterior displacement, or anteriorly displaced with reduction. D, is completely anteriorly displaced (Murakami *et al.*, 1993). (c). Angular measurement. Posterior angle: angle between points Cs, Cc, and Pd. Intermediate angle: angle between points Cs, Cc, and Md. Anterior angle: angle between points Cs, Cc, and Ad. Condyle line: line between points Cs and Cc. Collum line: a line which passes from the middle of the mandibular collum and parallel to a projection line that is tangent to the posterior border of mandibular collum. Alpha angle: angle between the condyle and collum line. (d) Classification of disc configuration.

rubber platform that was placed under the neck and the head. The cross-shaped marking light of the MR apparatus was set to pass through the mid-sagittal plane of the face and Frankfort horizontal plane. The MRI of the TMJ was obtained by means of a 1.5 T super-conductive MR scanner (GE Medical System, Milwaukee, WI, USA). The MRI protocol included closed mouth parasagittal T1-weighted spin echo sequences (TR/TE: 500/21, Matrix 256×128, FOV 10×10) taken perpendicular to the long axis of the condyle. Slice thickness was 3 mm with no inter-slice gap.

The chin cup treatment continued until six months after the elimination of the anterior crossbite and Class III molar relationship. MRIs were obtained again at the end of treatment, which lasted for an average of 16 months. The measurements and assessments of the MRIs are presented in Figure 1a–c. Classification of disc configurations are shown in Figure 1d.

Statistical methods

Student's *t*-test was used to compare the measurements between the groups at the beginning and end of the study, whilst the changes occurring during the course of the treatment and control periods were evaluated by means of the paired *t*-test.

Error of the method

The MRIs of all subjects were traced and measured three times and the method error was calculated by means of variance analysis. The repeatability coefficient (r) was calculated by the following formula:

$$(r) = \Sigma^2_{\text{total}}/\Sigma^2_{\text{between}}$$

With this method, the repeatability coefficient was found to be high.

Results

The results indicate that the treatment and control subjects had different alpha angles at the beginning and end of the study. The difference was statistically significant ($P < 0.05$). However, the differences between the groups in terms of other measurements were not statistically significant (Table 1).

According to the results of the paired *t*-test, no significant changes were found in the disc position (posterior, medial, and anterior angles) in either group or condyle shape (alpha angle; Table 2). This finding shows that neither in the treatment group nor the control group, the relationship between the disc and the condyle underwent any change.

The evaluation of the regional disc position and configuration in the treatment and control groups at the beginning and end of the study are presented in (Tables 3 and 4, Figures 2 and 3). These data indicated that at the beginning of treatment the disc was located in 80 per cent of subjects in compartment A and 20 per cent in B, whereas the post-treatment location was 47 per cent in compartment A and 53 per cent in B.

Table 1 Data obtained at the beginning and end of the study compared with a Student's *t*-test.

Measurements	Pre-treatment			Post-treatment		
	Treatment group $x \pm Sx$	Control group $x \pm Sx$	*P*	Treatment Group $x \pm Sx$	Control Group $x \pm Sx$	*P*
Alpha angle	166.23 ± 2.15	172.59 ± 1.97	*	163.00 ± 2.16	172.00 ± 2.68	*
Posterior angle	2.22 ± 1.77	6.12 ± 2.71	NS	5.44 ± 1.63	4.55 ± 2.13	NS
Medial angle	55.43 ± 2.73	54.51 ± 1.60	NS	53.97 ± 2.57	53.74 ± 1.77	NS
Anterior angle	94.44 ± 2.41	96.08 ± 2.73	NS	89.93 ± 2.66	95.49 ± 2.53	NS

*$P < 0.05$: significant.
NS: not significant.

Table 2 Data obtained during the study evaluated in each group with a paired *t*-test.

Measurements	Treatment group		Control group	
	$D \pm S_D$	*P*	$D \pm S_D$	*P*
Alpha angle	–3.23 ± 1.67	NS	–0.59 ± 1.83	NS
Posterior angle	+3.22 ± 2	NS	–1.57 ± 1.30	NS
Medial angle	–1.46 ± 1.77	NS	–0.77 ± 1.06	NS
Anterior angle	–4.51 ± 2.23	NS	–0.59 ± 2.35	NS

NS: not significant.

Table 3 Evaluation of the disc position and configuration in treatment group.

	Pre-treatment		Post-treatment	
Disc position	80%	A	44%	A
	20%	B	53%	B
Disc configuration	27%	Bi-planar	20%	Bi-planar
	73%	Bi-concave	80%	Bi-concave

Table 4 Evaluation of the disc position and configuration in control group.

	Pre-observation		Post-observation	
Disc position	90%	A	90%	A
	10%	B	10%	B
Disc configuration	100%	Bi-concave	100%	Bi-concave

The disc configuration was 27 per cent bi-planar and 73 per cent bi-concave at the beginning of treatment, while at the end of treatment, it was 20 and 80 per cent, respectively, which is considered to be a normal disc shape. In the control group, there was no change in the TMJ disc position and configuration.

Discussion

In this study, MRI was used to examine the effects of chin cup treatment on disc position and configuration. The most important issue in this context is the imaging of the junction of the posterior band with the bi-laminar zone. MRI is a perfect tool for the imaging of this area (Helms and Kaplan, 1990). Drace and Enzmann (1990) stated that the junction of the posterior band with the posterior attachment produced a hypo-intensity image compared with adjacent areas, and this hypo-intensive image was vertically located on the condylar head. They also reported that in a physiological disc-condyle relationship, this area, that is, the junction of the posterior band of the disc with its posterior attachment, should be at the 12 o'clock position with the condylar head. These researchers claimed that assuming the 12 o'clock position to be 0, ±10 degree deviations from this position should be considered normal. However, displacements greater than +10 degrees are described as anterior displacements, and those greater than –10 degrees as posterior displacements.

The findings of this study revealed that with chin cup treatment the posterior angle tended to increase (+3.22 ± 2), while the anterior and medial angles tended to decrease (–4.51 ± 1.77 and –1.46 ± 1.77, respectively). However, these changes were within normal limits and statistically insignificant (Tables 1 and 2). Moreover, they remained within the limits of a ±10 degree deviation from the 12 o'clock position reported by Drace and Enzmann (1990). On the other hand, when the changes in the location of the disc were evaluated using the method of Murakami *et al*. (1993), the disc position was found to be 47 per cent in compartment A and 53 per cent in compartment B at the end of treatment. Thus, although compartment A is an ideal location for the disc, compartment B is also considered normal. In line with the evaluations

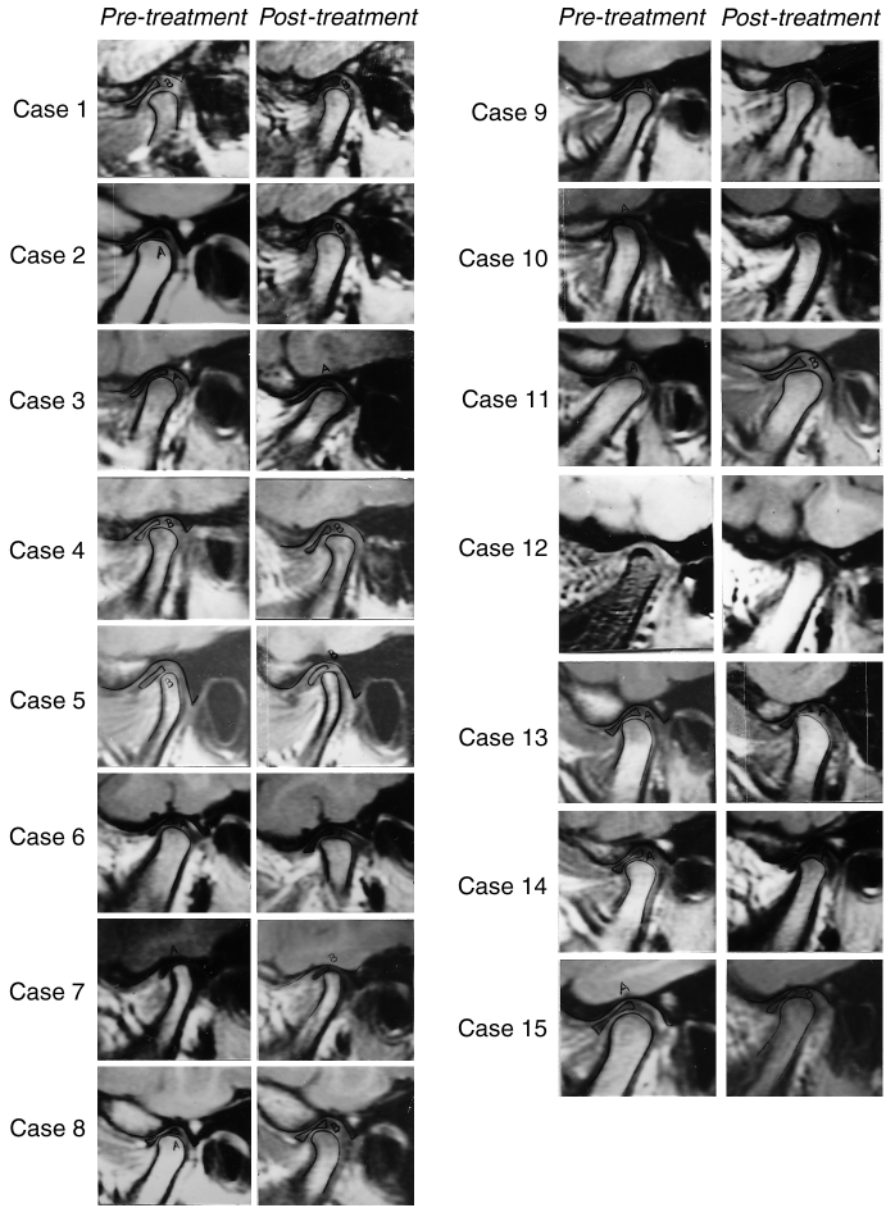

Figure 2 Disc position and configuration in chin cup patients as visualized on the sagittal unilateral (left) TMJ MRIs at the beginning (pre-treatment) and end of the study (post-treatment). The localization and configuration of the discs are marked on the tracing.

made with these two methods, it is believed that there was no undesirable change in the location of the disc during treatment with the chin cup. Thus, it can be said that the minimal changes observed in the location of the disc resulting from chin cup treatment did not lead to internal derangement in the TMJ. In fact, the clinical examinations carried out at the end of treatment revealed the TMJ to have remained healthy. It has been reported in experimental and laboratory studies that there is no cellular and/or structural changes in the posterior attachment

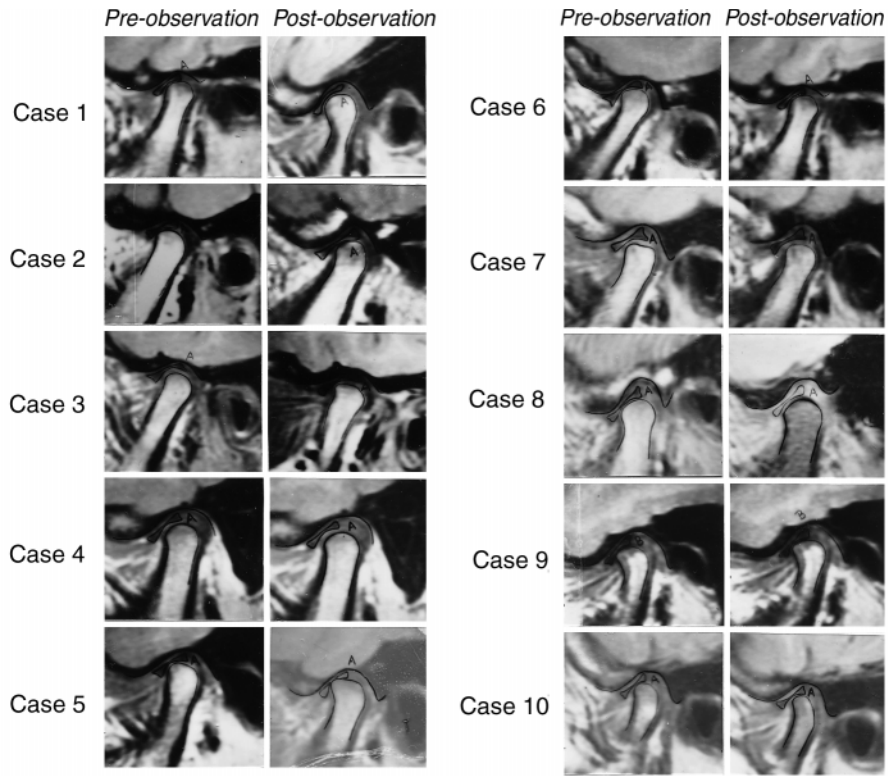

Figure 3 Disc position and configuration in orthognathic subjects as visualized on the sagittal unilateral (left) TMJ MRIs at the beginning (pre-observation) and end of the study (post-observation). The localization and configuration of the discs are marked on the tracing.

and posterior band of the disc due to stress (Joho, 1973; Tanne *et al*., 1993, 1996).

Another point in connection with the internal derangement of the TMJ is that any positional change of the disc is accompanied by configurational change (Murakami *et al*., 1993). Normal disc shape is bi-concave (Manzione *et al*., 1986; Drace and Enzmann, 1990; Witzig and Spahl, 1991; Murakami *et al*., 1993). In this investigation it was found that the post-treatment disc configuration was, to a great extent (80 per cent), bi-concave. It was also found that unchanged measurements of the medial and anterior angles not only make the achievement of the ideal disc configuration possible, but also allow its maintenance.

The mandibular condyle is located on the mandibular ramus perpendicular to it (Manzione *et al*., 1986; Witzig and Spahl, 1991). However, due to functional changes in the stomatognathic system and mandibular rotations, angular relationships between the mandibular condyle and the condylar neck also change (Björk, 1963). Hiroshi and Toshio (1996) stated that orthognathic forces applied during chin cup treatment were concentrated particularly on the posterior surfaces of the glenoid fossa, and the mandibular condyle and the collum. They also claimed that thinning of the collum occurred due to local remodelling. Petrovic *et al*. (1975) stated, in an experimental study of young Sprague–Dawley rats with the chin cup, that the lateral pterygoid muscle was strained, which created a stimulating effect on the condylar periosteum, leading to bone deposition on the anterior surface of the condyle. In this investigation it was found that when the two groups were compared at the beginning and end of the study, there were differences in the alpha angle; however, there were no significant changes in either group during the treatment and

observation periods. Considering these findings, it can be suggested that condylar morphology differs in different skeletal structures.

It may be said that if the retractive orthognathic forces applied to the mandibular condyle are of such strength and in such direction as to cause an abnormal positional relationship between the condyle and the disc, there is a possibility that this will lead to internal derangement of the TMJ by causing morphological changes in the mandibular condyle, and morpho-positional and positional changes in the disc. However, if it is remembered that the maximum level of stress applied by the chin cup is smaller than those caused by normal functions such as biting and mastication (Boyd *et al*., 1990), chin cup treatment will not deleteriously affect the area in question when sufficient stress is applied to maintain the anatomic and physiological relationship among the various components of the TMJ.

Conclusions

It was shown in this study that if the chin cup is employed during the early periods of growth and if the magnitude of the applied chin cup force does not exceed the physiological limits, no positional and configurational changes will occur in the disc. This being the case, the belief that chin cup treatment will cause internal derangement of the TMJ can be regarded as unfounded. However, it would be useful to follow up the long-term results of such cases.

Address for correspondence

Dr Hatice Gökalp
Ankara Üniversitesi
Diş Hekimliği Fakültesi
Ortodonti Anabilim Dalı
06500 Beşevler-Ankara
Turkey.

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