

# Sagittal position of the temporomandibular joint disc after treatment with an activator: an MRI study

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## **Abstract:**

**Background:** The relation of cause and effect between orthodontic treatment and joint dysfunction, especially disc displacement, is not proved yet. The orthodontic treatment that imposes stress on the temporomandibular joint is the mandibular advance to correct the classes II by mandibular retrognathia. The study aimed to explore the effect of mandibular advancement using rigid activator associated with extra-oral forces on the sagittal position of temporomandibular joint (TMJ) disc.

**Methods:** 63 children, 10.6 +/- 1 years old with class II and mandibular retrognathia were selected from primary schools. An imaging magnetic resonance exploration (MRI) was performed on 126 TMJ before treatment (t1) and one year after treatment (t2). The data were analyzed by the Statistical Package for the Social Sciences (SPSS). The error risk  $\alpha$  was 5%. The Friedman's Chi2 Test for paired data was used. The difference p was considered significant if  $p < .05$ .

**Results:** At t2, the discs generally occupied a more anterior position remaining within the bounds of normality and 5 of them have presented a displacement.

**Conclusion:** Overall, after one year of mandibular advancement, the discs have maintained a normal position.

**KEY WORDS:** Temporomandibular joint; Magnetic resonance imaging; Activator; Class II.

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## 1. INTRODUCTION

Activators of growth are used to treat Class II division 1 malocclusion in children with mandibular retrognathia. They represent the first phase of treatment, usually followed by a second phase with fixed therapeutic. Although different in their design as explained in the Lautrou [1] classification, activators are based on the same principle: the mandibular advancement.

Many articles [2, 3, and 4] on their effectiveness and efficiency are regularly published. Their effects on dental and maxillofacial structures have been and continue to be the object of studies [6-10]. We found among these effects an adaptation of the of the temporomandibular joint (TMJ) components. However, the exploration of all the TMJ components, especially the disc, was only possible with magnetic resonance imaging or MRI. In 1994 Buthiau [11] devoted a book exploring the temporomandibular joint (TMJ) by magnetic resonance imaging (MRI). The principles, indications and contraindications of MRI of TMJ are found in various publications [12-15].

The relation of cause and effect between orthodontic treatment and joint dysfunction, especially disc displacement, is not proven as demonstrated by

McNamara [16] in a review of the literature and Kim [17] in a meta-analysis, but it wasn't definitively refuted.

Our study is part of this reflection and was interested in relationships established between TMJ disc and mandibular condyle in children treated by rigid activator associated with extra-oral force using MRI exploration. The study received the agreement of the medical experts committee of medicine, Algiers faculty.

## **2. MATERIALS AND METHODS**

### **Subjects**

The sample consisted of 63 children (girls and boys) from 23 primary schools. The age's mean was 10.6 years +/- 1. The subjects included had: skeletal mandibular retrognathia, ANB higher or equal to 5 °, a higher or equal to 5mm over jet, Class II molar, facial growth should be medium or horizontal type. On clinical examination, patients had to be free of signs of joint dysfunction.

Before treatment, the TMJ MRI exploration should objectify right and left joint without disc displacement. Patients who have undergone orthodontic treatment or suffering from general illness were not included.

### **Methods**

Two orthodontic assessments were carried out: at t1 before treatment by activator and at t2, a year after treatment. The TMJ clinical examination was performed at t1 and t2. Profile radiographs were taken at t1 and t2. Ricketts's analysis complemented by some values of Steiner's analysis was used.

### **Appliance**

The same type of activators, a rigid activator associated with headgear [18, 19] was used in this study for all patients; the aim was to promote the mandibular growth. Maxillary and mandibular tray, made in resin, was solidarized after articulated models in mandibular advancement. Extra-oral forces were added.

In this appliance, no wire accessories have been included. The retention was ensured by the faithful reproduction of the indentations and the sufficient recovery of the teeth by the resin.

### **MRI exploration**

It was made with 1.5 Tesla imager at the National Center of Imaging. The same imager was used at time t1 and t2. The exploration was bilateral, using a double surface coil. The same radiologist conducted reading MRI images. Concerning the reproducibility and accuracy of measurements of the angles for the same patient, the kappa test was used. The kappa value was  $k=0,81$  for the intraobserver. The concordance was good. Each study included:

- A sequence identification in the transverse plane
- A T1-weighted sequences gradient echo with contiguous cuts 1.5mm thick in the sagittal and coronal plane in the closed mouth (CM). The same sequences were repeated in open mouth (OM), (Figure 1a,1b).

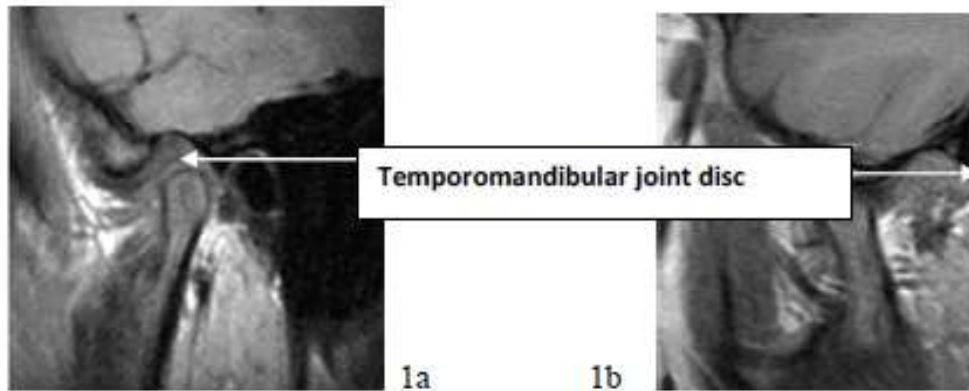
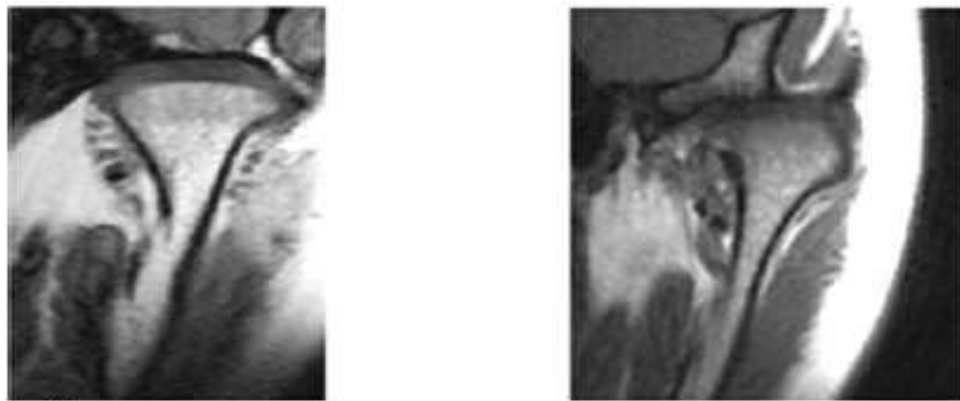


Fig.1: MRI image of TMJ of a 10 year old child. (1a CM and 1b OM).

Coronal sections oriented along the long axis of the condyle in OM and CM were also conducted in gradient echo, T1-weighted to assess the transversal disc position and eliminating false negatives (Figure 2a, 2b).



1 a2 b

Fig.2: MRI coronal images of TMJ. 2a CM, 2b OM.

### **Evaluation criteria of the position of the TMJ disc**

The sagittal position of the disc was evaluated in the CM by the angle formed by the vertical line passing by the estimated center of the condyle, the Y-axis or 12 o'clock of Shannon [20] and the junction zone between the zone bilaminar and posterior band, and the center of the condyle. These two lines, constructed an angle which evaluated the disc position (Figure 3) were described by Drace [21]. In this study, the angle was appointed sagittal angle. In the CM an angle in front of the axis 12 o'clock was positively noted, a posterior angle to this axis was negatively noted. In OM the disc was considered in normal position if it came between the condyle temporal and mandibular condyle.

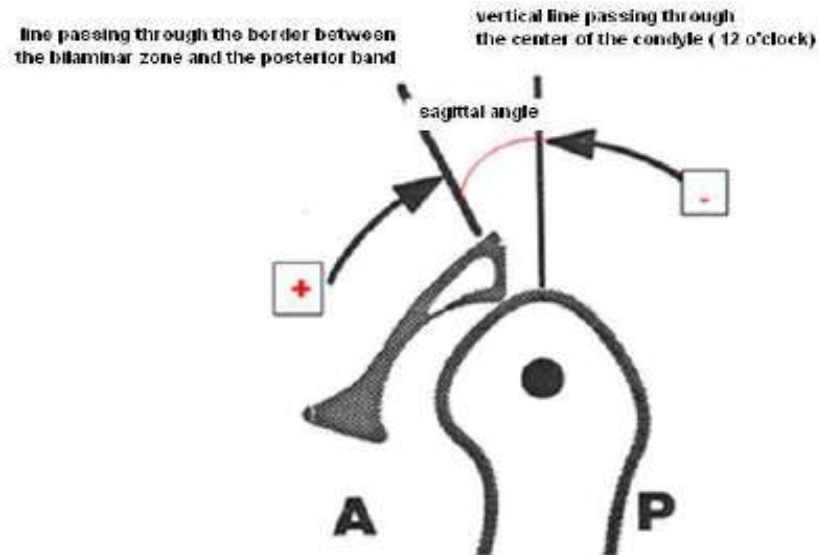


Fig.3: Drawing of sagittal angle according to Drace [21]

The transversal position was considered normal when the disc was situated inside the two lines tangent to the condyle.

### Statistical study

The statistical unit was the temporomandibular joint. The study was conducted by the software Statistical Package for the Social Sciences (SPSS). The  $\alpha$  granted error risk was 5%. The Chi2 test of Friedman for paired data was used. The difference  $p$  was considered significant if  $p < .05$ .

## 3. RESULTS

### Distribution of patients

The sample comprised 63 children, 35 girls and 28 boys that is to say 126 TMJ joint discs. The gender distribution gave 55, 6% girls and 44.4% boys.

### Sagittal angle before treatment mouth closed

At t1, the sagittal angle defining the position of the disc presented values ranging from a minimum of  $- 11.3^\circ$  to a maximum of  $+ 14^\circ$ . The mean value was  $2.7^\circ \pm 7$ . To be able to represent the results in tables and graphs (Table 1), values of the sagittal angle were grouped into two classes:  $]-14, 0]$  and  $] 0, 14]$ . using brackets according to mathematical standards.

(Tab.I) Distribution of sagittal angle values, frequencies and proportions at the time t1 in CM

Sagittal Angle	Numbers of patients	Percentages
$]-14, 0]$	45	35%
$] 0, 14]$	81	65 %

Mean of sagittal angle at t1:  $2.7^\circ \pm 7$ .

### Sagittal angle after treatment, mouth closed

At t2, new values outside of  $]-14, 14]$  have been identified, with a minimum of  $-30^\circ$  and a maximum of  $42.2^\circ$ . The sagittal angle mean value was  $10.4^\circ \pm 15.2$ . The comparison of means revealed a significant difference,  $p=10^{-6}$ . At this stage, several sagittal angles have therefore seen their value changed and new classes of angles were established. They were also ordered into classes.

The new classes  $[-30; -14]$ ,  $]14; 30]$  and  $] 30; 43[$  were added to the two existing at t1:  $] - 14; 0]$  and  $] 0; 14]$  (Table II).

It appears that after a year of treatment with activator, 52 discs remained in the classes  $]-14.0]$  and  $] 0, 14]$ , representing the initial positions of the disc and 74 left these two starting classes. Of these 74 discs 11 were found in class  $[-30, -14]$ , 58 in the class  $]14, 30]$  and 5 discs in the class  $] 30, 43 [$ .

(Tab.II): Distribution of sagittal angle values, frequencies and percentages at the time t2 in CM

Sagittal Angle	effectifs	Percentages
$[-30 , -14]$	11	8,7%
$] -14 , 0]$	17	13,5%
$] 0 , 14]$	35	27,8%
$] 14 , 30]$	58	46%
$] 30 , 43[$	5	4%

Mean of sagittal angle at t2:  $10.4^\circ \pm 15$ . Comparison of means: \*\*\*\* $p < 0, 05$ .

### Position of the disc in OM

All Discs have capped the mandibular condyle.

### Correlative analysis

Only variables that revealed an “r”, indicating a correlation were reported. The analysis revealed a moderate correlation of the angular value at time t2 with gender ( $r = 0.241$ ), over jet ( $r = 0.293$ ) and overbite ( $r = 0.251$ ).

## 4. DISCUSSION

After the MRI protocol was explained to the children, no child has refused it. We haven't found 30% refusal as described by Franco [22]. The sample consisted of girls and boys, the ratio was 0.8. This ratio may suggest a greater frequency of Class II division1 in girls.

In our study, joint function was satisfactory after a year of mandibular advancement. For the function we agree with the findings of Pancherz [23] and Foucart [24]. Bourzgui and al [25] haven't found severe signs of joint dysfunction on the clinical examination of patients treated orthodontically. Some authors [26-28] spoke of moderate dysfunction. Clinical examination of the TMJ could not alone identify disc displacement and it can be observed in asymptomatic patients [29].

MRI allowed a more objective approach to the status of TMJ and variations of disc position. Regarding the position of the disc, the criterion of Drace [21], the most used, was often superimposed on the visual criterion by Shanon [20]. The sagittal angle as defined in our study was visually estimated in some studies, while in others it was measured. The normality was always reported to the visual criterion where the border between posterior band and bilaminar zone was in a position 11 to 12 o'clock. That is to say the value of sagittal angle is normal if it is of  $-30^{\circ}$  to  $0^{\circ}$ . Regarding to the errors of drawing the 12 o'clock lines and the individual variations, many authors showed other values [30-33]. In this study we have adopted the value used by Aidar [34], the normal sagittal angle was estimated normal if the famous board line between posterior band and bilaminar zone was between 11 and 1 o'clock. This may better describe individual variations and varying situations of the condyle line axis. In our study, we chose the normal value used by Aider (for the same reasons). In CM the position of the disc was normal if the border between bilaminar zone and posterior band of the disc was between 11 o'clock and 1 o'clock that is to say between  $-30^{\circ}$  to  $+30^{\circ}$ .

The mean of the sagittal angle at t1 and t2 showed a significant difference in our results. However, the mean at t2 remained within normal bounds. This suggests that the disc, while adopting a more forward position, remained in the normal-physiological range. The wide confidence interval showed many variations of the sagittal angle and comparison of means alone was not enough. Analysis of disc displacement was given by the details of the of 126 disc position organized in value class.

Thus, the results showed that 52 disks have not changed their position and sagittal angles remained in the starting classes. The displacement has affected 74 discs. Among them, 69 discs remained in the normal bounds and 5 discs showed anterior displacement in excess of  $+30^{\circ}$  or 1 o'clock and signing an anterior displacement for 5 joints with a difference  $p = 0.04$ . If we take into account variations due to the angle's lines, this difference does not express a frank significance. This trend in anterior displacement of the disc after wearing an activator is found in the Ruf's [35] study, justified by a condylar retrieve effect and not by disc displacement.

We found 11 disks with posterior position and sagittal angles ranging from  $-30^{\circ}$  to  $-14^{\circ}$  but within the normal values. This disc position was noted by Pancherz [23] who followed the disc position by MRI in children carrying an Herbiest appliance. He explained that the disc returned to its original position (before treatment) after fixed therapeutic.

Watted [30] found by MRI a mean sagittal angle of  $-18.8^{\circ}$ . He concluded that there was not pathological disc displacement after orthopedic treatment in patients with retrognathia.

In our study the mean of the sagittal angle increased from 2.17 at t1 to  $10,4^{\circ}$  at t2. The disc had generally occupied a more anterior position while remaining within the limits of the normality. We joined the conclusions of Foucart [24] where the mean sagittal angle was increased from  $6.7^{\circ}$  before treatment to  $9.3^{\circ}$  after treatment.

In our sample the five discs which have moved beyond the normal position corresponded to a proportion of 4%. This result was different from the results of Foucart [24] which was 20%. In addition, he found that the disc obeyed to the law of all or nothing, or it was strongly moved or it was not. In our study we found

different subgroups: with large, moderate and without change of disc position. This may be due to the individual response or the MRI protocol.

In his investigation Franco [22] used MRI as exploration. He found no disc displacement after treatment by Fränkel activator. Mandibular advancement, less aggressive and longer over time, can explain the difference with our previous study that found 5 disc displacements. It also stresses that the criterion, 11 to 12 o'clock by Shanon [20], purely visually estimated can cause misinterpretations. For this reason, he advised an angular value for judging the disc displacement. However, it states that variations can exist depending on the accuracy of the layout of the lines that make up this angle.

Wadhawan [31] found posterior disc displacement after activator treatment and the disc was returned to a more normal position after the fixed therapeutic. Kinzinger [36] following patients treated with fixed propulsive appliance concludes that no movement was observed after mandibular advancement and that any disc displacement before treatment could be corrected after bite jumping.

Aidar [34], while concluding the safety of treatment by Herbst appliance, added that at the end of the orthodontic phase, changes were observed in the disc shape and position and could expose some patients in the future to joint problems. These findings were similar to those of our study where we found five displaced discs. He emphasized that there was relationship between occlusion and joint disorders. According to him, an increased overjet could be the cause of a disc displacement. These conclusions were close to the results of our correlations. They have shown a link between disc position with overjet and overbite. As described by Patti [37], increased overbite maintains the mandible and the condyles in a retrieve position and may cause the anterior displacement of the articular disc.

Chavan [38] explored TMJ patients treated by Bionator and Twin Block and found to retrieve the disc position on MRI images with a more anterior position of the condyle after 6 months. The duration of treatment in our study is double.

We found a correlation between sex and sagittal angle. Girls were more prone to changes in the disc position. However, we must consider the increased number of girls in the sample.

In OM, all discs covered the condylar head, even the five displaced discs.

It is found that by comparing our results with those of authors which included MRI in their protocol, the disc position was different each time. The elasticity of normal values probably also has been the source of various conclusions.

The studied populations were not homogeneous, and appliances for advancing the mandibular were different. The MRI imager didn't have the same ability to visualize the disc. The studies used imaging at 0.5 Tesla to 1.0 Tesla and 1.5 Tesla. Therefore, the disc visibility was not the same.

This heterogeneity in methodology was raised by Michelotti [39] in his review of the literature on the relationship between orthodontic treatment and joint dysfunction. The multifactorial joint dysfunction and heterogeneity in methodology makes it difficult to identify its cause and effect, if it exists.

## 5. CONCLUSION

The relationship between disc displacement and orthodontic treatment is still discussed. In our sample the analysis by MRI of the disc behavior in children treated with rigid activator revealed an overall disc displacement which remains within the limits of normality.

However, the wholeness does not reflect the individual variations. Indeed, the supposed adaptability of the TMJ is not the same for all children treated with rigid activator; the individual angular values at the end of treatment in our study were ranged from  $-30^{\circ}$  to  $+43^{\circ}$ .

As a preventive measure and in order to avoid any particular dysfunction that could be related to mandibular advancement, the TMJ examination before, during and after treatment must be made carefully. The objective of reducing the over jet should not overshadow the TMJ condition specially the disc position.

## 6. Declaration of conflicts

No conflicts

## 7. Authors' biography

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