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# Assessment of occlusal appliance in repositioning of the temporomandibular joint anterior disc displacement with reduction: a 3 to 36 months follow-up

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**Rationale:** Occlusal appliance is one of methods for temporomandibular joint anterior disc displacement with reduction (ADDWR). However, most studies have focused on the symptom reliefs rather than the disc-condyle positional relationship. **Aim:** To evaluate the success rate and the prognosis of occlusal appliances in repositioning of the disc in temporomandibular joint ADDWR. **Materials and methods:** One hundred and forty four (144) patients (210 joints) diagnosed with temporomandibular joint ADDWR based on magnetic resonance imaging (MRI) were consecutively included in our study. For all joints it was confirmed by MRI that the disc could be recaptured in a mandible anterior position. Occlusal appliances, including anterior repositioning appliance, twin-block or Herbst, were worn to keep the mandible in this position. MRI scanning was carried out before, 6 months later, at the end of treatment and at the follow-up visit. Logistic regression was used to analyze the risk factors for success. Cox regression model was applied to estimate the prospective risk of failure. **Results:** Among the occlusal appliances used, there were 100 anterior repositioning appliances, 23 twin-blocks, and 21 Herbst, with mean treatment duration of  $9.5 \pm 2.6$  months. One hundred and seventy seven (177) joints (84.3%)

were successfully repositioned at the end of splint treatment, according to MRI. Logistic regression showed that the appliance types were significantly associated with the success rate. At 2 years of regular follow-up, in almost 53% of the cases the disc-condyle relationship was normal. Gender, age, treatment duration and orthodontics were identified in the final Cox regression model with hazard ratios of 1.375, 1.141, 0.396 and 0.364 respectively. **Conclusion:** Occlusal appliance is one of the useful methods to recapture the disc in patients with temporomandibular joint ADDWR. However, the patient selection should be rigorous.

**Key words:** temporomandibular joint, anterior disc displacement with reduction, mandible, occlusal appliances, anterior repositioning appliance, twin-block, Herbst, magnetic resonance imaging

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**Conflicts of Interest**

The authors declare that they have no conflict of interest.

**T**emporomandibular joint (TMJ) anterior disc displacement is one of the most common TMJ disorders, which has a high incidence in the normal population. Anterior disc displacement can be divided into anterior disc displacement with reduction (ADDWR) and anterior disc displacement without reduction (ADDWoR), depending on the positional relationship between the disc and the condyle when opening the mouth [1]. Patients with anterior disc displacement

mainly complain of such symptoms as clicking, joint pain, limited range of mouth opening, masticatory difficulty, mandible dysfunction, etc, which seriously disturb their lives.

Although many methods have been proposed for the treatment of anterior disc displacement [2–4], such as functional appliances, medications, physical therapy, arthrocentesis and disc repositioning, the optimal treatment procedure for anterior disc displacement remains controversial. Functional appliances, which



are usually used for treating skeletal class II malocclusion in juvenile patients, have attracted the attention of many TMJ doctors. S.L. Lin et al. [5] found that flat-plane splints with a vertical thickness of both 3 mm and 5 mm could effectively improve the symptoms of disc displacement without reduction, especially for joint crepitus and TMJ arthralgia. C. Zhang et al. [6] confirmed that splint therapy could increase maximal mouth opening and reduce both pain intensity and the frequency of clicking in patients with TMJ disorders. T. Haketa et al. [7] concluded that there was no difference in the relief of the TMJ symptoms between exercise and occlusal splints by conducting a randomized clinical trial. Although many reports have confirmed that occlusal splints can more or less improve clinical symptoms of TMJ anterior disc displacement, most of these studies focused on the symptoms rather than on the positional relationship between disc and condyle. H. Kurita et al. [8] once reported that functional appliances were able to successfully recapture discs in all 32 joints with disc displacement with reduction. However, the authors did not present any follow-up data for this population. In addition, there are no reports on the stability of the splint treatment either at short or long term.

In order to evaluate the success rate and the outcomes of occlusal splints in repositioning the ADDWR, we selected the patients who had undergone splint treatment for ADDWR to assess their positional relationship between disc and condyle at various time periods, including before and after treatment, or at follow-up. In this study, we only focus on the disc and condyle relationship, rather than the changes in their clinical symptoms.

## Materials and methods

### Patients

Consecutive patients who attended the TMJ Clinic at the Department of Oral Surgery in Shanghai Ninth People's Hospital from August 2009 to June 2016 for occlusal splint treatment were reviewed in our study. The inclusion criteria were as follows. First, the patients had been diagnosed with TMJ ADDWR based on magnetic resonance imaging (MRI) scanning according to the reported protocols [9]. Second, the patients had no history of conservative or surgical treatment for TMJ. Third, all the patients were required to take MRI scanning in a mandible anterior position to eliminate the joint clicking upon mouth opening; those whose MRI results confirmed a recaptured disc were recommended for splint treatment. Next, the patients had to accept occlusal appliance treatment. The patients were to be seen at least once after finishing of the splint treatment.

Those who gave up their treatments or were lost from the follow-up during the treatment were excluded in our study.

This study was conducted under the approval of the Ethics Committee of Shanghai JiaoTong University School of Medicine and with the Code of Ethics of the World Medical Association (Declaration of Helsinki). An informed consent was obtained from all patients in this study.

### Treatment process

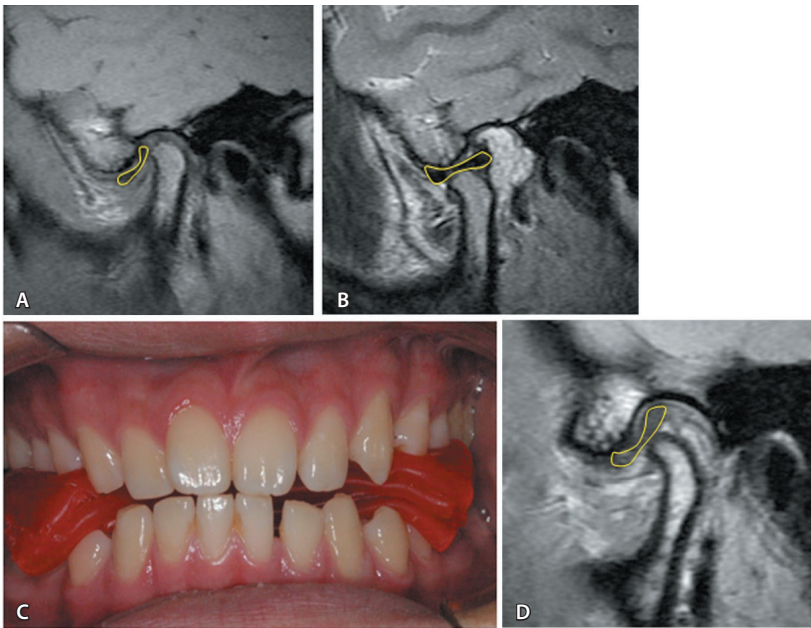
The patients who were diagnosed as TMJ ADDWR were required to take MRI scanning in a protrusive edge to edge position fixed by a wax (Fig. 1). If their MRI confirmed that the disc could be recaptured, than the functional appliances, including maxillary full-coverage anterior repositioning appliance (ARS), twin-block (TB) or Herbst (HB), were produced in this anterior position (Fig. 2). The occlusal surface of ARS or TB was ground by 1 mm approximately every 4 weeks for bite reconstruction. The patients were instructed to wear the splint 24 hours a day for at least 6 months. If bite reconstruction have not been finished, patients had to wear it for more time. MRI scanning was repeated at 6 months and at the end of splint treatment, respectively. Patients were required to come for regular follow-ups after finishing their treatments (Fig. 3). Orthodontics was recommended, but it depended on the patient's main complaints.

### MRI evaluation

All patients who were included into the study, had their MRI examinations before treatment, after 6 months of wearing the appliance, at the end of splint treatment and at their follow-up visit. MRIs were taken using a 1.5 T scanner (Signa; General Electric, Milwaukee, WI) with dual phased array dedicated TMJ surface coil receivers, according to the routine protocol [9]. For each patient, three sagittal planes and three coronal planes on MRI films in the same position before, during or after treatment were compared at these 3 different levels. The evaluation criteria proposed by S.Y. Zhang et al. [10] were recommended to assess the outcomes of splint treatments: 1) reposition in 3 sagittal planes is excellent; 2) reposition in 2 planes is good; 3) reposition in less than 1 plane or changing to ADDWOR is poor. Excellent and good evaluations were regarded as successes (if the disc displacement before treatment had been confirmed only in 1 or 2 levels, only replacement in all levels was deemed successful).

### Study variables

The predictor variable was the outcome of disc-condyle relationship depending on the splint treatment. The



**Fig. 1.** Magnetic resonance imaging (MRI) and clinical evaluation of the temporomandibular joint anterior disc displacement with reduction: **A** MRI showed the disc was anterior displacement in a mouth closed position; **B** MRI demonstrated that the disc returned to its normal position when opening the mouth; **C** the patient made his mandible protrusion in an edge to edge position to eliminate the joint clicking upon mouth opening and fixed by wax; **D** MRI was performed in this protrusive position and confirmed that disc could return to its normal position



**Fig. 2.** Various types of occlusal appliances were used to fix the mandible in this protrusive position: **A** maxillary full-coverage anterior repositioning appliance; **B** twin-block; **C** Herbst

independent variables included age, gender, treatment duration, appliance types, orthodontics (yes or not) and the follow-up period.

#### Statistical analysis

Statistical analysis was performed with R Core Team (2015) (R: A language and environment for statistical computing; R Foundation for Statistical Computing, Vienna, Austria). Logistic regression was used to analyze the risk factors of success rate by splint treatment. Cox proportional hazard regression model was used to estimate the risk of failure in their prognosis; successfully treated joints were censored at the time of their last available follow-up.

Initial assessment was processed by univariate analysis, with continuous variables evaluated as non-transformed, log-transformed and best-fit fractional polynomial transformations. Transformations did not significantly improve the model fit for any variable, so non-transformed data were used. The multivariate model development involved covariate assessment by statistical significance and clinical importance [11]. Variables and interaction terms were entered into the multivariate models if the univariate  $p$  value was  $<0.05$  or if there was significant clinical importance. For each added covariate, the likelihood-ratio (LR) test was used to evaluate the effect of removal on model fit. Covariates were included in the model if  $p < 0.05$ , the LR test indicated a significant improvement to model fit ( $p < 0.05$ ) and/or there was evidence of clinical relevance.

## Results

### Description of the patients

A total of 153 patients (223 joints) were enrolled in the present study, but 9 patients (13 joints) were lost during the treatment. Therefore, the final total sample included 210 joints in 144 patients (107 females and 37 males), aged from 9 to 53 years at their initial visit (mean  $\pm$  SD,  $19.5 \pm 7.1$  years). The types of occlusal appliances consisted of ARS in 100 cases (143 joints), TB in 23 cases (34 joints) and HB in 21 cases (33 joints). The treatment duration ranged from 6 to 16 months, with a mean duration of  $9.5 \pm 2.6$  months. Twenty six (26) patients accepted orthodontics after the splint treatment (Table 1).

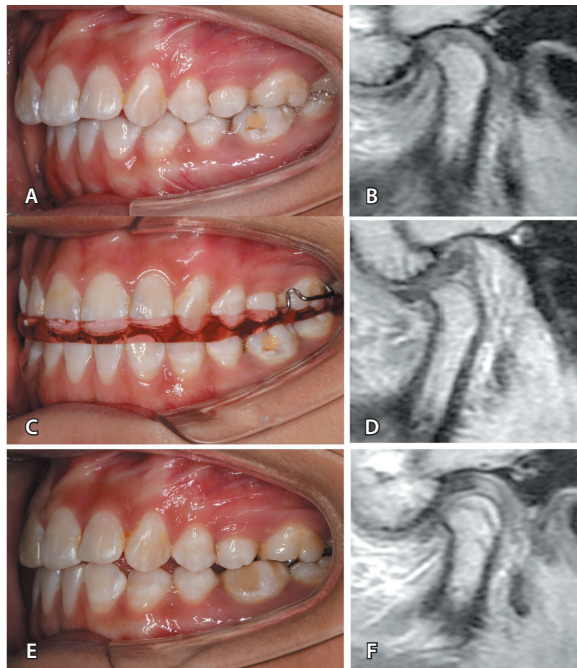
### Success rate of splint repositioning TMJ ADDWR

MRI results showed that 177 (84.3%) joints were successfully repositioned at the end of splint treatment and 33 (15.7%) joints failed to recapture during or at the end of splint treatment, according to our evaluation criteria. Logistic regression showed that the appliance types are significantly associated with the success rate. Compared to ARS, the hazard ratio (HR) for TB appliance was 0.226 (95% CI: 0.787, 0.065,  $p < 0.05$ ), and HR of HB appliance was 1.678 (95% CI: 3.718, 0.758,  $p = 0.202$ ). Age as a factor was also included into the logistic regression model, with a HR of 0.965 (95% CI: 1.015, 0.917,  $p = 0.167$ ) by multivariate analysis (Table 2).

### Assessment of the splint treatment for ADDWR at various follow-up periods

In order to assess the stability of the ADDWR repositioning with an occlusal appliance, MRI results of the 177 successful joints were evaluated at their





**Fig. 3.** A typical case of splint recapturing of the anterior displaced disc in patients with temporomandibular joint anterior disc displacement with reduction: **A** the occlusion before anterior repositioning appliance (ARS) treatment; **B** magnetic resonance imaging (MRI) showed that the disc was anteriorly displaced at the first visit; **C** the occlusion with wearing the ARS; **D** MRI showed that the disc became normal in a mandible protrusive edge to edge position; **E** the occlusion after ARS treatment; **F** MRI showed that the disc remained in the normal position at one year after splint treatment

last follow-up after the splint treatments. According to the last MRI follow-up, the cases were divided into the groups of a 3 to 6 month follow up, 7 to 12 months, 13 to 24 months, and more than 24 months. The

**Table 1.** Demographics of patients in the study

Variables	Patients	Percentage
<b>Gender</b>		
male	37	25.7%
female	107	74.3%
<b>Age</b>		
≤ 12	7	4.9%
13–20	91	63.2%
21–30	35	24.3%
31–40	8	5.5%
> 40	3	2.1%
<b>Occlusal appliances</b>		
ARS	100	69.4%
TB	23	16.0%
HB	21	14.6%
<b>Orthodontics treatment</b>		
	26	18.1%

ARS anterior repositioning appliance, TB twin-block, HB Herbst

success rates in these four groups were 84.8%, 75%, 72.1% and 53.1% respectively (Table 3). Cox regression analysis was then performed to calculate HRs for each variable. Univariate and multivariate analyses are shown in Table 4. Gender, age, treatment duration and orthodontics were included in the final Cox regression model with HRs of 1.375 (95% CI: 0.92–2.05,  $p=0.119$ ), 1.141 (95% CI: 0.98–1.33,  $p=0.099$ ), 0.396 (95% CI:

**Table 2.** Univariate and multivariate analyses of the success rate by logistic regression

Variables	Univariate analysis		Multivariate analysis	
	hazard ratio (95% CI)	$p$	hazard ratio (95% CI)	$p$
Gender: M vs. F	1.543 (0.79–3.03)	0.207		
Age	0.967 (0.92–1.01)	0.167	0.965 (0.92–1.02)	0.167
<b>Splint type:</b>				
HB vs. ARS	1.879 (0.86–4.11)	0.114	1.678 (0.76–3.72)	0.202
TB vs. ARS	0.247 (0.07–0.85)	0.027	0.226 (0.07–0.79)	0.019

M male, F female, ARS anterior repositioning appliance, TB twin-block, HB Herbst



**Table 3.** The follow-up results of splint in treating anterior disc displacement with reduction

Follow-up period	Success joints / total follow-up joints	Success rate
3–6 months	39/46	84.8%
7–12 months	42/56	75%
13–24 months	31/43	72.1%
> 24 months	17/32	53.1%

0.29–0.54,  $p < 0.0001$ ), and 0.364 (95% CI: 0.23–0.58,  $p < 0.0001$ ), respectively (Table 4, and Fig. 4).

### Discussion

Anterior disc displacement is one of the most common TMJ disorders which occur at all ages, but with a high prevalence in adolescents [12, 13]. In addition to mandible dysfunction, anterior disc displacement can also result in osteoarthritis and decreased condylar height. In the recent years, a link between anterior disc displacement and mandibular growth has been drawing increased attention [14, 15]. K.P. Schellhas et al. [16] have reported that anterior disc displacement was associated with a decreased ramus height and maxillofacial abnormalities. Q. Xie et al. [17] once investigated the prevalence of mandibular asymmetry in patients below 20 years of age with symptomatic unilateral anterior disc displacement and asymptomatic volunteers with normal disc-condyle relationship diagnosed by MRI; they concluded that mandibular asymmetry was much more common and severe in young patients with unilateral anterior disc displacement. To further

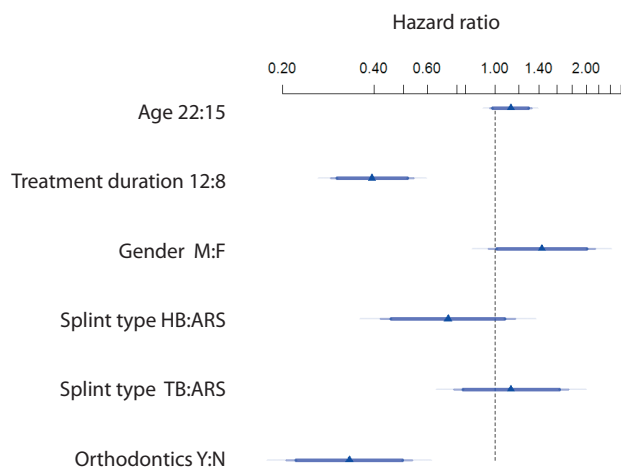
explore the reason of this phenomenon, Q. Xie et al. [18] conducted a longitudinal study to evaluate the change of TMJ morphological symmetry during the natural course of unilateral juvenile anterior disc displacement. At a mean follow-up of 12.22 months, they found that the occurrence of mandibular asymmetry increased from 86.36% to 93.18%, and middle line deviation increased from 5.58 mm to 7.74 mm after the follow-up. These studies suggested that anterior disc displacement can result in limited condyle growth and maxillofacial deformities in adolescents. As a result, it is important to restore the normal relationship between the disc and the condyle.

Functional appliances, being among the treatment methods for anterior disc displacement, have been deemed useful for relief of the TMJ symptoms. Many studies have confirmed that the symptom of clicking was improved by wearing the splint [19, 20]. However, what happens with the TMJ? Does the disc return to its normal position or its anterior displacement persists? The MRI confirmed evidence has been scarce. H. Kurita et al. [8, 21] reported that the disc could be recaptured in ADDWR patients by occlusal appliances. Z. Ma et al. [22] have found that the TMJ space was well distributed, and adaptive remodeling in TMJ occurred via functional treatment in patients with disc displacement with reduction. This is because the disc could return to its normal position when opening the mouth or in a mandible anterior position for ADDWR patients. Despite various kinds of occlusal splints, all the appliances have the effect of opening the bite either in the vertical or anteroposterior direction. However, there have been no reports on the long-term stability of functional appliances in terms of repositioning the displaced disc. In the

**Table 4.** Univariate and multivariate analyses of the success rate by Cox regression model

Variables	Univariate analysis		Multivariate analysis	
	hazard ratio (95% CI)	<i>p</i>	Hazard ratio (95% CI)	<i>p</i>
Gender: M vs. F	1.284 (0.88–1.88)	0.199	1.375 (0.92–2.05)	0.119
Age	1.178 (1.01–1.38)	0.038	1.141 (0.98–1.33)	0.099
Splint type:				
HB vs. ARS	0.739 (0.45–1.21)	0.23		
TB vs. ARS	0.745 (0.49–1.12)	0.161		
Treatment duration	0.438 (0.32–0.61)	0.0001	0.396 (0.29–0.54)	0.0001
Orthodontics: yes vs. no	0.439 (0.28–0.69)	0.0001	0.364 (0.23–0.58)	0.0001

M male, F female, ARS anterior repositioning appliance, TB twin-block, HB Herbst



**Fig. 4.** The Cox proportional hazard regression model to estimate the risk of failure in their prognosis of occlusal appliance repositioning the disc in patients with temporomandibular joint anterior disc displacement with reduction

present study, we used the splint to keep the mandible in an anterior position, in which the disc-condyle relationship was normal. The patients were instructed to wear the splint 24 hours a day for at least 6 months to complete the occlusion reconstruction and adaptive remodeling of the TMJ.

In our study, 84.3% of the ADDWR joints were successfully repositioned at the end of splint treatment, confirmed by regular MRI evaluations. Comparing various types of the appliances, we found that TB had the highest success rate, while HB showed an inferior treatment effect. This is because TB has a greater potential to open the bite both vertically or anteroposteriorly, and it can also provide the bite reconstruction by grounding the occlusal surface. Although HB can fix the mandible position and insure the wearing time, it has poor control in the vertical direction, which can result in intrusion of the molar teeth during a long wearing time. As the molar

teeth are intruded, the mandible is forced to clockwise rotation and the disc might be squeezed forward again. ARS has an intermediate potential to open the bite, compared to TB, and it can also provide occlusal reconstruction. Besides, ARS is worn only in the single upper jaw which makes the patients feel more comfortable. This is why almost two thirds of patients choose ARS. Except from the types of splints, there was a weak association between the patients' age and the success rates. The results showed that the success rate in younger patients was slightly higher than in the older ones.

As for the 177 successfully recaptured joints, we continued to monitor them to assess the stability of occlusal appliance repositioning ADDWR. The results showed that after 2 years of the follow-up, the percentage of normal disc-condyle relationship was 53%, according to the MRI scanning. By Cox regression analysis, gender, age, treatment duration and orthodontics were associated with the treatment stability. The treatment prognosis in female patients is better than in males. In addition, the treatment stability is higher in younger patients. Our results also implied that the longer treatment duration could benefit the outcomes. The reason for that might be that a longer time of wearing the appliance can ensure sufficient adaptive remodeling of the TMJ. After the splint treatment, patients who carried out orthodontic treatment had better prognosis. However, the types of occlusal appliances have no effect on the long-term stability, once they have successfully recaptured the disc.

## Conclusion

Occlusal appliance is one of the useful methods to recapture the disc in patients with ADDWR. However, the patient selection should be rigorous. In addition, a longer treatment duration and orthodontics therapy is recommended to make the occlusal reconstruction and TMJ remodeling complete. ©

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