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# **Incidence of anterior disc displacement without reduction of the temporomandibular joint in patients with dentofacial deformity**

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36

37 Short title : ADDwoR of TMJ in dentofacial deformity

38

## 39    **Abstract**

40    This study aimed to investigate the incidence of anterior disc displacement  
41    without reduction (ADDwoR) of the temporomandibular joint (TMJ) in  
42    patients with dentofacial deformity. Eighty-eight female patients (176 joints)  
43    with Skeletal Class III and 33 female patients (66 joints) with Skeletal Class  
44    II malocclusion with or without anterior open bite and asymmetry were  
45    evaluated. Magnetic resonance imaging (MRI) of the TMJ was used for  
46    diagnosis of ADDwoR. Statistical analysis was performed to examine the  
47    relationship between ADDwoR and skeletal structure. ADDwoR was present  
48    in 37 (56.1%) of the 66 joints in class II compared to 34 (19.3%) of the 176  
49    joints in class III ( $p < 0.05$ ). In class III, ADDwoR was significantly more  
50    common in joints with mandibular asymmetry (24 (32.4%) of 74) than in  
51    joints with open bite (9 (14.5%) of 62) and joints with open bite and without  
52    mandibular asymmetry (1 (2.6%) of 38). In class II, ADDwoR was  
53    significantly less common in joints with mandibular asymmetry and without  
54    open bite (1 (12.5%) of 8). ADDwoR was only observed on the deviated side in

55 both class III and class II with mandibular asymmetry. The prevalence of

56 ADDwoR was quite different according to dentofacial morphology.

57

## 58 INTRODUCTION

59

60 Dentofacial morphology and symptoms of temporomandibular disorder are thought to  
61 be related. Recent reports have shown that symptoms of temporomandibular disorder  
62 are highly associated with mandibular asymmetry<sup>1</sup>, open bite<sup>2</sup>, and Skeletal Class II  
63 malocclusion<sup>3</sup>, and less common with Skeletal Class III malocclusion<sup>2</sup>. However, these  
64 reports are only based on the relationship between subjective symptoms of  
65 temporomandibular disorder and dentofacial morphology. Few objective studies using  
66 MR imaging have been done.

67 Recently, we reported that anterior disc displacement without reduction (ADDwoR)  
68 and bone changes of the mandibular condylar head were significantly more common in  
69 patients with skeletal open bite than in volunteers without dentofacial deformity<sup>4</sup>. This  
70 shows that skeletal open bite is one of the factors associated with the incidence of  
71 ADDwoR and bone changes of the mandibular condylar head. However, bone changes  
72 of the mandibular condylar head are thought to generally occur secondary to ADDwoR<sup>5</sup>,  
73 but they can occur without ADDwoR. In the former, mandibular condylar resorption  
74 occurs following ramus height decreases; if this change is unilateral, it can cause facial

asymmetry, and if it is bilateral, it can cause open bite. In the latter, bone changes occur at a stage of development of the mandibular condylar head, and disc displacement is thought to occur after mandibular condylar resorption, but the details are unknown.

In this way, ADDwoR with dentofacial deformity is a very important factor to understand the development and function of the mandible. However, the incidence of ADDwoR in dentofacial deformity has not been sufficiently investigated. Therefore, an objective imaging study was performed to determine the relationship between the incidence of ADDwoR and dentofacial structure with dentofacial deformity.

## **MATERIALS AND METHODS**

The subjects in this study were 121 women with dentofacial deformity, including 88 with Skeletal class III malocclusion (176 joints) and 33 with Skeletal class II malocclusion (66 joints) with or without mandibular asymmetry and open bite, who underwent orthognathic surgery at Hokkaido University Hospital, Sapporo, Japan. The median age at the time of surgery was 25 years (range, 14-48 years). None of the patients had previously been diagnosed with juvenile rheumatoid arthritis. Patients with

sagittal skeletal deformities were included in this study. Mandibular asymmetry was defined as >2 mm deviation between the menton and facial midline, and open bite was defined as <0 mm overbite. No men were included in this study to avoid skewing the cephalometric measurements by sex-related differences. The subjects included some women with clinically detectable TMJ signs and symptoms (capsular pain, joint sounds, masticatory muscle tenderness) and some without symptoms. The TMJs of patients with dentofacial deformity were examined using MR imaging to assess the position of the disc before the start of orthodontic treatment. Tesla 3.0 MRI machine was used. The position of the disc was examined using sagittal and coronal slices and T1-weighted or proton-density MR imaging with the mouth closed and open. The slice thickness was 3 mm, and the slice gap was 0.5 mm on all MR images. The bilateral surface coil for TMJ was used. On PDWI, TR (repetition time) was 1300 msec, and TE (echo time) was 30 msec. On T1WI, TR (repetition time) was 700 msec, and TE (echo time) was 15 msec. Pixel size on both PDWI and T1WI was 512×192. Software processing of the MR images was not performed after the MRI had been completed. Results of MRI were classified as with or without ADDwoR by Radiologist who trained as an MRI specialist. Subjects were divided into the Skeletal class III group with mandibular asymmetry or

109 open bite and the Skeletal class II group with mandibular asymmetry or open bite.

110 ADDwoR was considered present if the disk was displaced anteriorly relative to the

111 posterior slope of the articular eminence and the head of the condyle, but without

112 reduction of the disk on mouth opening (Fig.1). The prevalence of ADDwoR was

113 examined in each group, and statistical analysis was performed using the Chi-squared

114 test. P values of less than 0.05 were considered significant.

115 This study comply with the principles stated in the Declaration of Helsinki Ethical

116 Principles for Medical Research Involving Human Subjects, adopted by the 18th World

117 Medical Assembly, Helsinki, Finland, June 1964, and as amended most recently by the

118 64th World Medical Assembly, Fontaleza, Brazil, October 2013.

119 The work has been approved by Hokkaido University Research Ethical Committee (Ref.

120 No. 010-0285).

121

## 122 **RESULTS**

123

### 124 **Prevalence of ADDwoR in patients with Skeletal Class III and Class II**

125 ADDwoR was observed in 34 (19.3%) of 176 joints in Skeletal Class III and in 37

(56.1%) of 66 joints in Skeletal Class II.; the difference was significant (Fig 2).

**Prevalence of ADDwoR in patients with Skeletal class III malocclusion and Skeletal class II malocclusion according to with or without open bite and facial asymmetry**

ADDwoR was significantly more common in Skeletal Class III with mandibular asymmetry (24 (32.4%) of 74 joints) than in Skeletal Class III with open bite (9 (14.5%) of 62 joints). ADDwoR was observed in 14 (50.0%) of 28 joints in Skeletal Class II with mandibular asymmetry and in 25 (59.5%) of 42 joints in Skeletal Class II with open bite; the difference was not significant (Table 1).

**Prevalence of ADDwoR in patients with Skeletal class III malocclusion according to with or without open bite and mandibular asymmetry**

ADDwoR was observed in 9 (14.1%) of 64 joints without open bite and asymmetry, 1 (2.6%) of 38 joints with open bite and without mandibular asymmetry, 16 (32.0%) of 50 joints with mandibular asymmetry and without open bite, and 8 (33.0%) of 24 joints with open bite and mandibular asymmetry. ADDwoR was observed only on the deviated

side in mandibular symmetry (Table 2).

**Prevalence of ADDwoR in patients with Skeletal class II malocclusion according to  
with or without open bite and mandibular asymmetry**

ADDwoR was observed in 11 (68.7%) of 16 joints both without open bite and  
mandibular asymmetry, 12 (54.5%) of 22 joints with open bite and mandibular  
asymmetry, 1 (12.5%) of 8 joints with mandibular asymmetry and without open bite,  
and 13 (65.0%) of 20 joints both with open bite and mandibular asymmetry. ADDwoR  
was only observed on the deviated side in mandibular asymmetry (Table 3).

**DISCUSSION**

It has been reported that symptoms of temporomandibular disorders are more frequent  
in patients with open bite and mandibular asymmetry, however these symptoms are less  
in patients with mandibular protrusion than in persons with normal occlusion<sup>6</sup>.  
Temporomandibular disorder has been found to be more common with open bite,  
mandibular asymmetry, and mandibular retrusion than with other dentofacial

deformities<sup>7</sup>. On the other hand, it has also been reported that there is no significant relationship between dentofacial deformity and temporomandibular disorder, though 62.8% of patients with dentofacial deformities had symptoms of temporomandibular disorder before orthognathic surgery<sup>8</sup>. One study found no relationship between cephalometric analysis and temporomandibular disorder<sup>9</sup>. Further, in patients with dentofacial deformities who underwent temporomandibular joint arthrography, 57% of patients had anterior disc displacement and 53% had temporomandibular joint pain, but there were no relationships among anterior disc displacement, clinical symptoms, and dentofacial morphology<sup>10</sup>. In contrast, anterior disc displacement was reported to be more common on the deviated side of temporomandibular joints with mandibular asymmetry on MR imaging<sup>11</sup>. A decreased posterior facial height and backward position and rotation of the mandible are principal characteristics associated with TMJ disk displacement<sup>12,13</sup>. Thus, opinions about the association between temporomandibular disorder and dentofacial deformity are divided.

Recently, we reported that anterior disc displacement was more common with open bite than in volunteers without dentofacial deformity, and bony changes were more common than with closed lock in patients with temporomandibular joint disorder<sup>4</sup>. We

177 want to verify prevalence of ADDwoR between Class III and Class II, because this  
178 previous study was predominantly Class II. Since the incidence of temporomandibular  
179 disorder is low in patients with mandibular protrusion<sup>2</sup> and high in patients with  
180 mandibular retrusion<sup>3</sup>, ADDwoR was 3 times more common in patients with  
181 mandibular retrusion than in patients with mandibular protrusion in this study. In the  
182 present study, Skeletal Class III and II groups were divided into those with or without  
183 open bite or mandibular asymmetry, because it is thought that the rate of  
184 temporomandibular disorder is generally high with open bite and mandibular  
185 asymmetry. The prevalence of ADDwoR was almost 2 times higher with mandibular  
186 asymmetry than with open bite in Skeletal Class III, but there was no significant  
187 difference in Skeletal Class II. This result indicates that the association of ADDwoR  
188 with mandibular asymmetry is stronger in Skeletal Class III than in Skeletal Class II. In  
189 the Class III patient, the open bite and the development of asymmetry is related to the  
190 excessive growth pattern of the condyles and the facial morphology<sup>14</sup>. Open bites in  
191 Class III patients are more commonly associated with accelerated condylar and  
192 mandibular growth and high occlusal plane angle facial morphologies. Class III patients  
193 with low occlusal plane angle facial morphologies do not commonly demonstrate an

194 open bite. Mandibular asymmetry in Class III patients is almost always related to  
195 excessive or accelerated growth of the condyle and mandible on the non-deviated side,  
196 that over-loads the contralateral (deviated) side that can cause the anterior disc  
197 dislocation<sup>15</sup>. Thus, Class III's with open bites and asymmetries are commonly  
198 associated with accelerated growth of the condyles. In the Class II patients, open bites  
199 and asymmetries are commonly related to TMJ pathologies that are causing condylar  
200 resorption (the opposite of what causes the open bites and asymmetries in the Class III  
201 patients). The most common causes of condylar resorption in the Class II patient are:  
202 1. Adolescent internal condylar resorption (AICR) where articular discs are anteriorly  
203 displaced (and commonly non-reducing) by the nature of the TMJ pathology. 2.  
204 Reactive arthritis with or without anteriorly disc dislocation. 3. Connective tissue  
205 autoimmune diseases<sup>14,15</sup>. Thus, the development of the open bite and asymmetry in  
206 Class III patients has a totally different TMJ etiology as compared to the Class II  
207 patients.

208 Furthermore, Skeletal Class III and Skeletal Class II were classified into 4 groups to  
209 determine the incidence of ADDwoR in this study. With mandibular asymmetry, the  
210 prevalence of ADDwoR was only observed at deviated side. The prevalence of

211 ADDwoR in Skeletal Class III with open bite alone was only 2.6%, and half that rate  
212 was seen without both open bite and mandibular asymmetry. This incidence is  
213 extremely low because the incidence of ADDwoR in volunteers without dentofacial  
214 deformity was reported to be 7%<sup>11</sup>. This suggests that the prevalence of ADDwoR in  
215 Skeletal Class III associated only with open bite is extremely small. Given this, it is  
216 desirable to investigate the details of the temporomandibular joint in dentofacial  
217 morphology to determine the etiology of overgrowth of the mandible. It would be  
218 expected that skeletal Class III patients with or without ADDwoR associated only with  
219 anterior open bite is extremely small. Symmetric prognathic cases rarely have anteriorly  
220 displaced discs; however, in the Class III asymmetry case, where the condyle on the  
221 non-deviated side overgrows creating the asymmetry, increases the loading on the  
222 opposite joint that contributes to the anteriorly displacement of the disc on the  
223 contralateral side. However, in the Class II patient with asymmetry, the ADDwoR is  
224 involved with the condyle on the deviated side that may be undergoing unilateral  
225 condylar resorption causing a shift of the mandible in the Class II patient, frequently  
226 related to AICR versus reactive arthritis versus connective tissue autoimmune disease<sup>16</sup>.  
227 In Skeletal Class II, the prevalence of ADDwoR with mandibular asymmetry alone

228 was 12.5%, with no bilateral cases. However, it was observed in 54.5% to 68.7% of the  
229 other 3 groups, with bilateral cases found in Skeletal Class III. These results indicate  
230 that the process of ADDwoR expression differs between Skeletal Class III and Skeletal  
231 Class II. An investigation of more detailed temporomandibular joints in Skeletal Class  
232 II associated only with mandibular asymmetry would be useful in the future. Skeletal  
233 Class III and Skeletal Class II had ADDwoR only on the deviated side with mandibular  
234 asymmetry. These results suggest that unilateral over-development of the  
235 condyle/mandible in Class III patients and unilateral condylar resorption in Class II  
236 patients is strongly associated with ADDwoR.

237 It is known that condylar cartilage is important as the starting point of mandibular  
238 bone development, and endochondral ossification, which was observed mainly on the  
239 mandibular condyle, is important for the development of mandibular bone. Whether  
240 mandibular bone formation on the displacement side decreases because a disorder  
241 occurs in the cartilage of the condyle due to anterior disc displacement or mandibular  
242 asymmetry occurs first is unknown, but these results mean that it is important to  
243 elucidate these clinical conditions, whether they occur at the same time because anterior  
244 disc displacement occurs continuously after the abnormality has occurred or in the

245 formation of the condyle. It would be desirable to follow-up the temporomandibular  
246 joints of young patients with mandibular asymmetry and anterior disc displacement in  
247 the future.

248 The degenerative change of the mandibular condyle is thought to have a close  
249 relationship to ADDwoR<sup>17</sup>, but ADDwoR without degenerative change of the  
250 mandibular condyle has also been reported<sup>3</sup>. Katzberg et al<sup>18</sup> and Kurt et al<sup>19</sup> reported  
251 vertical shortening of ramus height by regressive change, and that growth suppression  
252 of the mandibular condyle with progression of the temporomandibular disorder may  
253 cause open bite. Chen et al<sup>3</sup> reported that condylar degenerative changes may lead to  
254 deformities of the jaw, in turn resulting in decreased vertical dimensions of the proximal  
255 mandibular segments and open bite. We assume that probably most of these patients are  
256 Class II's with either AICR, reactive arthritis, or CT/AI. We reported that bone changes  
257 occurred in 79% of temporomandibular joints with ADDwoR and open bite, ADDwoR  
258 appeared and increased the mandibular plane angle, bone changes developed and  
259 increased the ramus plane angle, and some patients with skeletal open bite showed worn  
260 facets and no protuberances on the incisal edges<sup>20</sup>. These results suggest that clockwise  
261 rotation occurred, resulting in mandibular condylar resorption for various reasons in

262 ADDwoR in patients who had dental articulation contact of the incisal edges in both the  
263 maxilla and mandible. Vertical malocclusion develops as a result of the interaction of  
264 many different etiologic factors, including thumb and finger sucking, lip and tongue  
265 habits, airway obstruction, and true skeletal growth abnormalities<sup>21</sup>. However, this is not  
266 clear, since mandibular condylar resorption with progression of temporomandibular  
267 disorder is one of the causes of open bite when looking at the present and previous  
268 results. We need to investigate more to pediatric patients because the onset of "vertical  
269 malocclusion" in teenage and adult patients, is more likely associated in Class II  
270 patients with condylar resorption. In a study using a three-dimensional finite element  
271 model of mandibular bone including the temporomandibular joint, compression stress in  
272 the posterior region and tensile stress in the frontal region at the temporomandibular  
273 joint increased according to the mandibular plane angle or the gonial angle<sup>22</sup>. These  
274 reports suggest that it can become one of the factors in which some dentofacial  
275 morphologies cause temporomandibular disorders. It seems reasonable to suggest that  
276 skeletal Class II profiles and hyperdivergent growth patterns are likely associated with  
277 an increased frequency of TMJ disc displacement and degenerative disorders<sup>23</sup>. In the  
278 present study, it was found that the expression of ADDwoR was very different with

279 differences in dentofacial morphology. These results show that dentofacial morphology  
280 is closely associated with anterior disc displacement, and that the state of the  
281 temporomandibular joint is extremely important in the development of dentofacial  
282 structure. In the future, it is particularly necessary to investigate the kind of change that  
283 occurs over the long term in dentofacial morphology by observing the  
284 temporomandibular joints of patients with open bite and mandibular asymmetry and  
285 temporomandibular disorders to better determine the relationships with  
286 temporomandibular disorder or the development of dentofacial structure.

287

288

289

290    **Conflict of interest**

291    We declare that we have no conflicts of interest.

292    **Role of the funding source**

293    There was no source of funding for this research.

294    **Ethical approval**

295    Approval was given by Hokkaido University Hospital Ethics Committee (Ref.

296    No 010-0285)

297    **Patient consent**

298    Not required.

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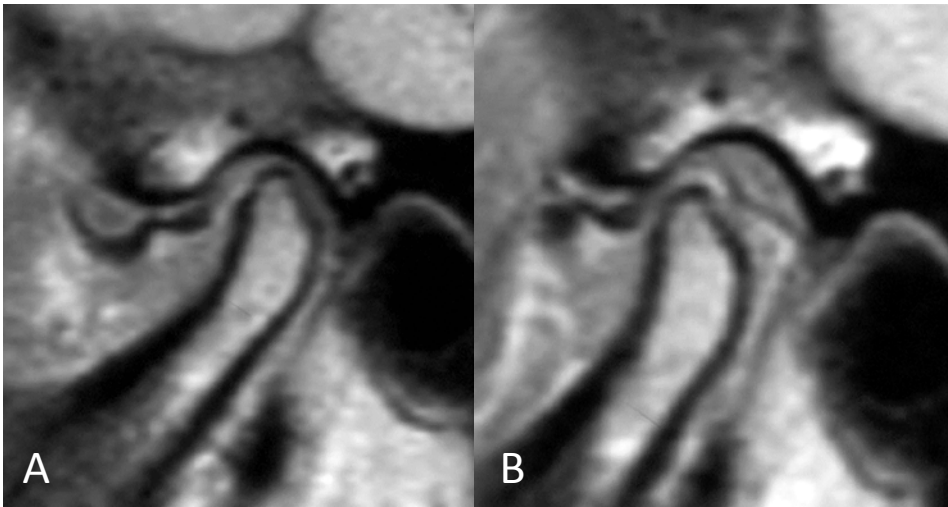
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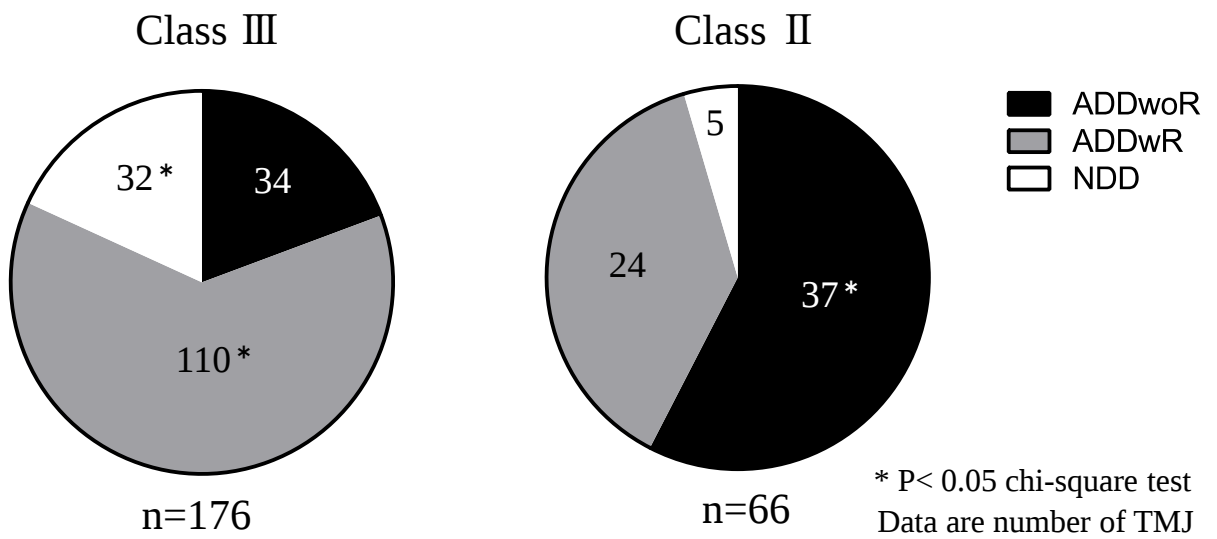
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*Fig 1.* MR images of Anteriorly Displaced Discs without Reduction (ADDwoR).  
(A: mouth closed, B: mouth open)

ADDwoR was considered present if the disk was displaced anteriorly relative to the posterior slope of the articular eminence and the head of the condyle, but without reduction of the disk on mouth opening.



*Fig. 2. Prevalence of TMJs with ADDwoR in patients with Skeletal class III and II*

ADDwoR: Anteriorly Displaced Discs without Reduction

ADDwR: Anteriorly Displaced Discs with Reduction

NDD: Non-Displaced Discs

Table 1. Prevalence of joints with ADDwoR in patients with Skeletal class III and II according to with or without open bite and mandibular asymmetry.

|        | Class III    |              | P value  | Class II     |              | P value |
|--------|--------------|--------------|----------|--------------|--------------|---------|
|        | OB<br>(n=62) | MA<br>(n=74) |          | OB<br>(n=42) | MA<br>(n=28) |         |
| ADDwoR | 9 (14.5)     | 24 ( 32.4)   | 0.0152 * | 25 ( 59.5 )  | 14 (50.0)    | 0.4319  |
| ADDwR  | 41 ( 66.1 )  | 42 ( 56.8 )  | 0.2643   | 12 ( 28.6 )  | 13 ( 46.4)   | 0.1266  |
| NDD    | 12 ( 19.4 )  | 8 ( 10.8 )   | 0.1612   | 5( 11.9)     | 1 ( 3.6 )    | 0.2224  |

ADDwoR: Anteriorly Displaced Discs without Reduction  
ADDwR: Anteriorly Displaced Discs with Reduction  
NDD: Non-Displaced Discs  
OB: open bite   MA: mandibular asymmetry

\* P< 0.05 chi-square test  
Data are number of TMJ (%).

Table 2. Prevalence of TMJs with ADDwoR in patients with Skeletal class III according to with or without open bite and mandibular asymmetry.

|                      | ADDwoR<br>(n=TMJ) | bilateral |       |     | unilateral       |                |               |              |               |
|----------------------|-------------------|-----------|-------|-----|------------------|----------------|---------------|--------------|---------------|
|                      |                   | ADDwoR    | ADDwR | NDD | ADDwoR/<br>ADDwR | ADDwoR/<br>NDD | ADDwR/<br>NDD | ADDwoR<br>DS | ADDwoR<br>NDS |
| OB/MA(-/-)<br>(n=32) | 9 / 64 (14.1)     | 3         | 18    | 7   | 3                | 0              | 1             |              |               |
| OB/MA(+/-)<br>(n=19) | 1 / 38 (2.6) *    | 0         | 13    | 4   | 1                | 0              | 1             |              |               |
| OB/MA(-/+)<br>(n=25) | 16 / 50 (32.0)    | 4         | 10    | 2   | 8                | 0              | 1             | 8            | 0             |
| OB/MA(+++)<br>(n=12) | 8 / 24 (33.0)     | 2         | 5     | 1   | 3                | 1              | 0             | 4            | 0             |

ADDwoR: Anteriorly Displaced Discs without Reduction  
ADDwR: Anteriorly Displaced Discs with Reduction  
NDD: Non-Displaced Discs  
OB: open bite MA: mandibular asymmetry  
DS: deviated side NDS: non-deviated side  
(+) : with (-) : without

Data are number of patients (%).

\* P< 0.05

Table 3. Prevalence of TMJs with ADDwoR in patients with Skeletal class II according to with or without open bite and mandibular asymmetry.

|                      | ADDwoR<br>(n=TMJ) | bilateral |       |     | unilateral       |                |               |                  |   |
|----------------------|-------------------|-----------|-------|-----|------------------|----------------|---------------|------------------|---|
|                      |                   | ADDwoR    | ADDwR | NDD | ADDwoR/<br>ADDwR | ADDwoR/<br>NDD | ADDwR/<br>NDD | ADDwoR<br>DS NDS |   |
| OB/MA(-/-)<br>(n=8)  | 11/ 16 (68.7)     | 5         | 2     | 0   | 1                | 0              | 0             |                  |   |
| OB/MA(+/-)<br>(n=11) | 12 / 22 (54.5)    | 5         | 2     | 1   | 2                | 0              | 0             |                  |   |
| OB/MA(-/+)<br>(n=4)  | 1/ 8 (12.5)*      | 0         | 3     | 0   | 1                | 0              | 0             | 1                | 0 |
| OB/MA(+/+)<br>(n=10) | 13 / 20 (65.0)    | 3         | 0     | 0   | 6                | 1              | 0             | 7                | 0 |

ADDwoR: Anteriorly Displaced Discs without Reduction

ADDwR: Anteriorly Displaced Discs with Reduction

NDD: Non-Displaced Discs

OB: open bite MA: mandibular asymmetry

DS: deviated side NDS: non-deviated side

(+) : with (-) : without

Data are number of patients (%).

\* P< 0.05