Original Article

Mandibular Dental Arch Changes with Active Self-ligating Brackets Combined with Different Archwires

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ABSTRACT

Objective: The aim was to compare mandibular arch and incisor inclinational changes by comparing active self-ligating brackets used with different forms of archwires with a control group in nonextraction cases. **Materials and Methods:** The sample of 50 patients with Class I malocclusion was divided into three groups: Group I was treated with active self-ligating brackets (Nexus, Ormco/Orange, CA, USA) used with Damon arch form copper nickel-titanium (Cu-NiTi) and stainless steel (SS) wires; Group II was treated with interactive self-ligating bracket system (Empower, American Orthodontics, Sheboygan, Wis, USA) used with standard Cu-NiTi and SS wires; and Group III was treated with Roth prescribed conventional brackets (Forestadent, Pforzheim, Germany) with standard Cu-NiTi and SS wires which was designed as a control group. Changes in dimension of mandibular arch and inclination of incisors were assessed on dental models and lateral cephalometric radiographs at pretreatment (T1) and posttreatment (T2) periods. Paired-t test and one-way analysis of variance were used to perform intragroup and intergroup comparisons, respectively. **Results:** In all groups, an average increase of transversal distances occurred from pretreatment to the posttreatment period ($P < 0.05$). However, mandibular arch length increase was significantly different among the Groups I-III ($P = 0.008$) and I-II ($P = 0.006$). No significant intergroup difference was found with regard to incisor inclinational changes. **Conclusions:** Bracket type had no significant effect on the mandibular dimensional or incisor inclination changes. Besides this, archwire type had only little effect on the treatment results as active self-ligating bracket with Damon archwires increased mandibular arch length greater than other groups.

Keywords: *Active self-ligating bracket, Damon archwire, mandibular arch dimension*

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Introduction

Self-ligating brackets are widely used nowadays, and two main types of ligation methods are current which are active and passive. These bracket systems differ from each other with regard to their clip property, wire type, and sequences.[1]

Nickel-titanium (NiTi) archwires are routinely used during leveling and alignment stages in orthodontic treatment with several positive properties such as low-elasticity modulus, high springback, and wide force-level ranges.[2-4] In addition, NiTi archwires with broader arch forms such as "Damon arch form copper NiTi (Damon Cu-NiTi)" are used by clinicians early in treatment because this type of archwires are claimed to expand and reshape the arches with the use of passive self-ligating brackets.[5]

Broad archwires can be used in the treatment of a moderate crowding in patients who refuse the use of interproximal enamel reduction or intraoral appliances

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for transverse arch expansion and incisor proclination to resolve the crowding on a nonextraction basis. Studies using broad Damon arch form Cu-NiTi have reported significant increases in maxillary arch dimensional and incisor inclination changes regardless of the bracket type: conventional, active and passive self-ligating brackets.[6,7] However, these studies comparing the effects of broad archwires with self-ligating and conventional brackets have been restricted to the maxillary arch.

There are also several studies showing the effects of passive self-ligating brackets on mandibular arch with the comparison of conventional brackets.[8-12] However, the influence of active self-ligating brackets with the use of different forms of Cu-NiTi archwires on the mandible has not been well documented. Therefore, the aims of this retrospective controlled trial were to quantify dimensional mandibular arch changes and inclinational changes of the incisors by directly comparing active self-ligating brackets used with broad Damon Cu-NiTi archwires and interactive self-ligating brackets used with standard Cu-NiTi archwires with a control group treated with conventional brackets and standard Cu-NiTi archwires in nonextraction cases. The null hypothesis of the present study was that neither bracket nor archwire type had any significant effect on mandibular dental arch changes.

Materials and Methods

Totally 50 patients selected from the files of Department of orthodontics at Hacettepe University were included in this retrospective study. This study was carried out in accordance with the ethics board of Hacettepe University (GO 16/264-02). The inclusion criteria were as the following: (1) aged between 13 and 18 years; (2) treatment with fixed appliances on a nonextraction basis; (3) with a permanent dentition; (4) moderate mandibular crowding (2–6 mm according to the Hayes-Nance analysis); (5) Angle Class I molar and canine relationship; and (6) treated by two authors (B. A-G., E. A.) of the study. The number of subjects was determined with *a priori* sample size calculation using G Power 3.1 (IBMM-SPSS for Windows software, version 21 (SPSS Inc., IL, USA)). based on a previous study.[13] Based on a mean difference of 1.8 mm mandibular length between conventional and self-ligating groups, it was found that a minimum of 16 subjects in each group was needed with a significance level of 5% and a power of 80%. The demographic variables of the patients are shown in Table 1.

Group I included 15 patients with a mean age of 14.38 ± 1.47 treated with the 0.022-inch slot Roth prescribed active self-ligating brackets (Nexus, Ormco/Orange, CA, USA). The archwire application for group I was as the following: 0.014-inch, 0.018-inch, 0.014 × 0.025-inch, and 0.017 × 0.025-inch Damon Cu-NiTi (Ormco), followed by 0.017 × 0.025-inch and 0.019 × 0.025 inch Damon stainless steel (SS) archwires (Ormco). Group II included 18 patients with a mean age of 14.74 ± 1.14 treated with the 0.022-inch slot Roth prescribed interactive self-ligating brackets (Empower, American Orthodontics, Sheboygan, Wis). Group III included 17 patients with a mean age of 14.46 ± 1.16 treated with the 0.022-inch slot Roth prescribed conventional brackets (Forestadent, Pforzheim, Germany), which was designed as a control group. In all groups, molar bands with 0.022-inch slot Roth prescribed tubes were attached to all first molar teeth. For the treatment of groups II and III, sequentially, standard 0.014 Cu-NiTi, 0.018-inch Cu-NiTi, 0.014 × 0.025-inch Cu-NiTi, 0.017 × 0.025-inch Cu-NiTi (Ormco) archwires followed by 0.017 × 0.025, and 0.019 × 0.025-inch SS (Ormco) archwires were used. Damon Cu-NiTi archwires were wider in the region distal to the canines when compared to standard types of Cu-NiTi archwires. The conventional brackets were ligated with SS ligature wires. The application of archwire sequence and the treatment protocol were the same for all the treatment groups. No anchorage mechanics, intermaxillary elastics or stripping were used during the treatment of the patients.

Changes in mandibular intercanine, inter-first premolar, inter-second premolar, intermolar widths, mandibular arch depth and mandibular arch length were assessed on the dental casts taken before and after treatment using a digital caliper (150 mm ISO 9001 electronic caliper; Tesa Technology, Renens, Switzerland) [Figure 1]. Measurements were made in duplicate, and the average values were used for the statistical analysis. Quick Ceph Studio Software (Quick Ceph System, San Diego, CA, 20139, USA) was used to digitally trace pre- and post-treatment lateral cephalometric radiographs of each subject to assess the changes in inclinational changes of mandibular incisors [Figure 2]. The following cephalometric measurements were performed: (1) IMPA, (2) FMIA°, (3) L1-NB (mm), (4) L1-NB°. All the dental and cephalometric measurements were carried out by one blinded operator (E. A.).

Statistical analysis

The measurements were repeated 4 weeks after in randomly selected 10 patients in each group. Spearman's and Pearson intraclass correlation values were between 0. 821 and 0.999, and this result confirmed the reliability of the measurements. All statistical analyses were performed with IBM-SPSS for Windows software, version 21

(SPSS Inc., Chicago, IL, USA). All the measurements except for L1-NB were normally distributed ($P > 0.05$) according to the Shapiro–Wilk test.

For the demographic variables and initial data, parametric one-way analysis of variance (ANOVA) was used to determine the intergroup differences. Levene, variance homogeneity test, was used for determination of the homogeneity and it was provided for all measurements except for ANB angle ($P < 0.05$). Thereof, for the analysis of the ANB variable, Welch ANOVA test was applied.

To evaluate the statistical significance of the dependent data between pre- and post-treatment periods within the groups, paired-t-test was used. Only for the evaluation of L1-NB (mm) in Group I from pre- to post-treatment period, Wilcoxon test was used. To compare the statistical differences between the groups, one-way ANOVA was used. In case of differences between the groups, LSD of *post hoc* test was used to determine the group, which created the difference. $P < 0.05$ was considered statistically significant.

Results

The groups showed no significant differences with regard to chronological age, mandibular crowding, and treatment duration [Table 1] as well as the initial values of cephalometric measurements [Table 2].

The mean pretreatment (T1) and posttreatment (T2) scores for the inclination of mandibular incisors, and transverse dimensional changes are given in Tables 3 and 4.

Mandibular incisors significantly proclined ($P < 0.05$) in all treatment groups, however, statistical

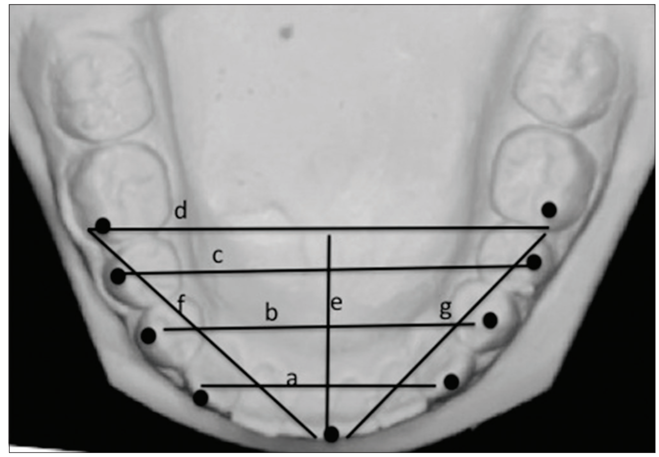

Figure 1: Dental model measurements. (a)-(3-3 width): Linear distance between the cusp tips of the mandibular canines. (b)-(4-4 width): Linear distance between the cusp tips of the mandibular first premolars. (c)-(5-5 width): Linear distance between the cusp tips of the mandibular second premolars. (d)-(6-6 width): Linear distance between mesiobuccal cusp tips of the mandibular first molars. (e)-(mandibular arch depth): Linear distance from the interincisal midline to the line joining the mesial contacts of the first molars. f + g-(mandibular arch length): Linear distance along the midline from the interincisal midline to the mesial contact of the first molars

Table 1: Demographical data of the groups

Variables	Group I	Group II	Group III	P*
Number of subjects	15 (12 female, 3 male)	18 (15 female, 3 male)	17 (13 female, 4 male)	
Age (year)	14.38±1.47	14.74±1.14	14.46±1.16	0.682
Mandibular crowding (mm)	4.11±0.99	3.75±1.16	3.31±0.69	0.080
Duration of treatment (months)	14.13±4.22	15.06±3.40	14.88±3.48	0.760

Values are presented as mean±SD or number. *One-way ANOVA. Group I=Active self-ligating bracket + Damon Cu-NiTi; Group II=Active self-ligating bracket + Cu-NiTi; Group III=Conventional bracket + Cu-NiTi. ANOVA=Analysis of variance; Cu-NiTi=Copper nickel-titanium; SD=Standard deviation

Table 2: Comparison of the initial data

Variable	Group I	Group II	Group III	P
IMPA (°)	94.25±6.04	97.83±5.67	92.95±6.29	0.054
FMIA (°)	60.97±9.25	60.37±6.28	63.02±6.41	0.542
L1-NB (°)	25.27±7.06	26.15±5.60	23.56±3.48	0.453
L1-NB (mm)	6.34±6.23	5.39±2.49	5.03±2.17	0.630
ANB (°)	2.96±2.89	3.09±0.92	2.15±1.65	0.148
Mandibular 3-3 (mm)	25.61±2.41	24.78±1.71	24.97±2.52	0.545
Mandibular 4-4 (mm)	32.82±2.65	32.42±2.36	32.43±2.38	0.877
Mandibular 5-5 (mm)	38.15±2.97	37.84±2.92	38.06±2.04	0.939
Mandibular 6-6 (mm)	43.79±3.50	43.06±2.58	43.69±3.11	0.750
Mandibular arch depth (mm)	20.85±1.88	22.20±1.56	20.89±2.21	0.068
Mandibular arch length (mm)	57.03±4.34	58.29±3.29	57.23±3.91	0.591

Values are presented as mean±SD or number. Group I=Active self-ligating bracket + Damon Cu-NiTi; Group II=Active self-ligating bracket + Cu- NiTi; Group III=Conventional bracket + Cu-NiTi. SD=Standard deviation; Cu-NiTi=Copper nickel-titanium

Table 3: Lateral cephalometric measurements of the groups at T1 and T2 periods

Variables	Before treatment (T1)	After treatment (T2)	*P*†	Delta	*P*‡
IMPA (°)					
Group I	94.25±6.04	100.24±5.28	<0.001	5.99±4.00	0.340
Group II	97.83±5.67	101.88±6.59	<0.001	4.04±2.95	
Group III	92.95±6.29	97.90±7.27	<0.001	4.95±4.25	
FMIA (°)					
Group I	60.97±9.26	55.56±9.02	0.005	-5.41±6.22	0.362
Group II	60.37±6.28	56.25±6.51	<0.001	-4.11±4.03	
Group III	63.02±6.41	56.55±6.29	<0.001	-6.48±4.28	
L1-NB (°)					
Group I	25.27±7.06	31.48±5.93	<0.001	6.21±5.09	0.308
Group II	26.15±5.60	29.98±5.17	0.001	3.83±4.13	
Group III	23.56±5.72	28.87±6.18	<0.001	5.31±4.25	
L1-NB (mm)					
Group I	6.34±6.23	8.47±5.79	<0.001	2.13±1.12	0.317
Group II	5.39±2.49	6.58±2.15	0.010	1.19±1.74	
Group III	5.03±2.17	6.72±2.23	<0.001	1.69±0.86	

Values are presented as mean±SD or number. †Comparisons between pre- and post-treatment measurements within groups, According to the paired *t*-test $P<0.05$ was considered as statistically significant, ‡Comparisons among group regarding for changing in clinical measurements, according to the one-way ANOVA $P<0.05$ was considered as statistically significant, *Wilcoxon test. Group I=Active self-ligating bracket + Damon Cu-NiTi; Group II=Active self-ligating bracket + Cu- NiTi; Group III=Conventional bracket + Cu- NiTi. ANOVA=Analysis of variance; Cu-NiTi=Copper nickel-titanium; SD=Standard deviation

Table 4: Dental model measurements of the groups at T1 and T2 periods

Variable	Before treatment (T1)	After treatment (T2)	*P*†	Delta	*P*‡
Mandibular 3-3 (mm)					
Group I	25.61±2.41	27.40±2.00	<0.001	1.79±1.69	0.242
Group II	24.78±1.71	26.37±1.36	<0.001	1.59±1.05	
Group III	24.97±2.52	26.01±1.48	0.017	1.04±1.60	
Mandibular 4-4 (mm)					
Group I	32.82±2.65	35.44±2.39	<0.001	2.62±1.36	0.765
Group II	32.42±2.36	34.62±1.71	<0.001	2.20±1.93	
Group III	32.43±2.38	34.79±1.47	<0.001	2.35±1.59	
Mandibular 5-5 (mm)					
Group I	38.15±2.97	41.28±2.50	<0.001	3.12±1.52	0.129
Group II	37.84±2.92	39.78±2.67	<0.001	1.94±1.71	
Group III	38.06±2.04	40.27±1.63	<0.001	2.20±1.82	
mandibular 6-6 (mm)					
Group I	43.79±3.50	45.90±3.07	<0.001	2.11±0.95	0.382
Group II	43.06±2.58	44.52±2.27	<0.001	1.46±1.38	
Group III	43.69±3.11	45.36±3.11	<0.001	1.66±1.58	
Mandibular arch depth (mm)					
Group I	20.85±1.88	22.88±1.77	<0.001	2.02±1.32	0.114
Group II	22.20±1.56	23.26±1.51	0.001	1.05±1.13	
Group III	20.89±2.21	22.07±2.62	0.010	1.18±1.67	
Mandibular arch length (mm)					
Group I	57.03±4.34	61.07±3.94	<0.001	4.04±1.76	I–III (0.008)*
Group II	58.29±3.29	60.55±2.31	<0.001	2.25±1.40	I–II (0.006)*
Group III	57.23±3.91	59.52±4.31	<0.001	2.29±2.12	

Values are presented as mean±SD or number. †Comparisons between pre- and post-treatment measurements within groups, According to the paired *t*-test $P<0.05$ was considered as statistically significant, ‡Comparisons among group regarding for changing in clinical measurements, According to the one-way ANOVA $P<0.05$ was considered as statistically significant, *LSD analysis (*post hoc*). Group I=Active self-ligating bracket + Damon Cu-NiTi; Group II=Active self-ligating bracket + Cu- NiTi; Group III=Conventional bracket + Cu- NiTi. LSD=Least significant difference; ANOVA=Analysis of variance; Cu-NiTi=Copper nickel-titanium; SD=Standard deviation

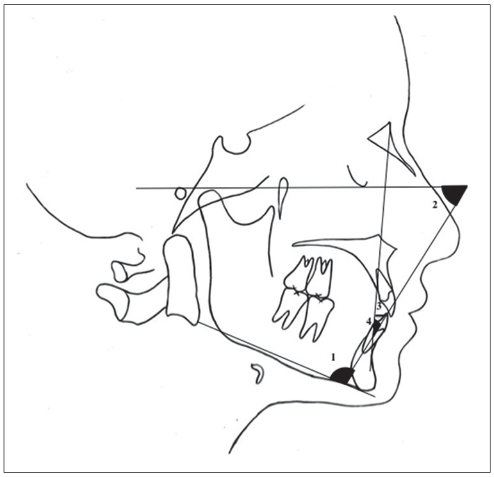

Figure 2: Lateral cephalometric measurements. (1) IMPA°**:** Angle between the axis of the lower incisor and the mandibular plane angle, (2) FMIA°**:** Angle between the axis of the lower incisor and the Frankfurt horizontal plane, (3) L1-NB (mm): Distance from labial surface of the lower central incisor to NB line, (4) L1-NB°: Angle between the axis of the lower incisor and NB line

analysis showed no significant intergroup differences [Table 3].

In all treatment groups, an average increase of dental transversal distances occurred from T1 to T2 period, which was considered statistically significant (Table 4; $P < 0.05$). No statistically significant differences were found on intercanine, interpremolar, intermolar widths, and mandibular arch depth measurement among the groups. However, mandibular arch length increase was significantly different among the Groups I-III ($P = 0.008$) and I-II ($P = 0.006$) [Table 4].

Discussion

This study was performed to reveal the dimensional changes with active self-ligating brackets combined with different forms of Cu-NiTi archwires. The treatment protocol in the present study design could be discussed since broad Damon archwires are rarely used with active self-ligating bracket systems. We thought that the result would lead to a comparison of the effects of different form of archwires used with the same properties of self-ligating brackets, which were in an active and interactive clip form. The manufacturers claim that interactive brackets passively capture smaller wires in leveling stages, however actively engage larger wires during finishing stages. The conventional bracket group was also evaluated and served as a control group. Therefore, the effects of the active self-ligating brackets with different forms of Cu-NiTi archwires could be compared among each other, also with a control group.

A significant increase in the mandibular arch measurements for both active self-ligating and conventional bracket systems was found; and there was no significant difference among three different treatment groups except for the mandibular arch length. This result indicated that the use of broad Damon or standard Cu-NiTi with active self-ligating bracket systems did not yield to significantly different orthodontic treatment results with regard to arch width. De Almeida *et al*.[14] compared self-ligating and conventional bracket systems regarding transversal mandibular changes with both CBCT images and dental cast measurements and used broad Damon archwires in both treatment systems. Similar to our results, they reported that bracket type had no significant influence on changes in mandibular dental arch. However, the clip property of their self-ligating bracket system, which can be manufactured as fully passive, fully interactive, or a combination of both systems was not classified in that study.

Pandis *et al*.[11] compared the effects of passive self-ligating brackets with broad Damon archwire and conventional brackets with standard archwire on mandibular dental arch variables and found no significant differences between the groups with respect to the proclination of the mandibular incisors similar as to our results. On the other hand, they noted greater intermolar width increases in the self-ligating group. Similarly, Fleming *et al*.[9] found greater expansion in the mandibular molar region with passive self-ligating brackets than conventional systems by the use of same standard form of archwires in both groups. In contrast to these findings, conventional bracket system did not differ from the self-ligating bracket groups used with different forms of archwires related to mandibular molar expansion in the present study. This difference may be related with the use of different type of self-ligating bracket (with an active clip) in the present study.

Pandis *et al*.[12] used the same broad Damon arch form of Cu-NiTi archwires with passive self-ligating and conventional bracket systems in another study. They found no difference of intercanine and intermolar arch width changes. They concluded that dental arch expansion was largely due to use of broad-shaped archwires. It is known that Damon archwires have a special property of broad arch shapes, particularly localized in the buccal segments. Therefore, it might be expected that the use of broad forms of Damon archwires can contribute the increased amount of expansion in the posterior segments of the arches. As a consequence, broad archwires with active self-ligating brackets were compared with narrower archwires with the same clip properties of brackets in the present study to exactly reveal if broad archwires would expand the mandibular arch significantly more than narrower archwires. However, transverse dimensional changes did not significantly differ from each other when these two groups were compared. Only mandibular arch length increase was significantly greater in Group I (active self-ligating bracket and broad archwire group) than in Group II and III. This result may be related with slightly greater incisor proclination and intercanine/intermolar width increases in Group I than other groups as Ricketts *et al*.[15] and Germane *et al*.[16] indicated that both incisor advancement and arch expansion mostly increase arch length. The smaller mandibular incisor torque value of Group II (-1 degree for Empower, 0 degree for Nexus Bracket) might affect the smaller increase in mandibular arch length.

In the studies of Fleming *et al*.[7] and Atik *et al*.,[6] active self-ligating brackets were used with broad Damon archwires, and no difference in maxillary arch dimensional changes was found between active, passive and conventional self-ligating bracket systems. It can be concluded from the studies that active self-ligating brackets can expand the maxillary arch as much as passive self-ligating brackets when used with broad archwires. Hence, in the present study, it may be expected that active self-ligating brackets with broad archwires (Group I) might yield to significantly greater mandibular arch expansion related to the form of archwire. However, arch width increase was slightly greater in Group I than group II and III but was not statistically significant. This difference may result from the fact that the present study evaluated mandibular arch instead of maxillary arch. It is emphasized that buccal expansion of the mandibular arch can be affected by several factors such as anatomy of the structures, oral musculature configuration, inclination of the dental arches.[17] Therefore, it may be wrong to suppose that broad-shaped archwires could provide greater dental arch widths.

Besides the dimensional arch changes, lower incisor inclinations were also evaluated in the present study. One of the ideas of the dental product manufacturers with active self-ligating brackets is that transmission of the torque value can be increased. Badawi *et al*.[18] found better torque control with active self-ligating brackets. On the other hand, other authors[19,20] stated that closing mechanism of the self-ligating brackets does not result in significant torque differences.

In the present study, there was an overall significant increase in incisor proclination in both active self-ligating and conventional groups. Cattaneo *et al*.[21] emphasized a significant mandibular incisor proclination, moreover the claimed torque control with active self-ligating brackets could not be shown in that study. Two studies[6,7] compared active self-ligating and conventional brackets with regard to incisor inclination and concluded that incisor proclination was similar with both appliance systems in accordance with our findings. However, note that the present research evaluated the mandibular arch by using Cu-Niti archwires in the conventional bracket group.

Active self-ligating brackets showed similar effects with regard to dental arch changes with the use of different forms of archwires, therefore, clinicians can prefer either of bracket or archwire types while treating moderate mandibular arch crowding. However, it should be kept in mind that the increase in the mandibular arch width is one of the main cause of unstable treatment results.[22,23] Therefore, all transverse widths obtained by active treatment in the present study should be interpreted with caution in terms of long-term stability.

One limitation of the present study might be related to its retrospective design. The best effort was made during the selection of the patients to overcome the pitfalls resulting from the study design. Patients treated by only two examiners in the same clinic with the same treatment protocol using the same archwire sequences were selected to eliminate bias. In addition, the other limitation was that two different brands of self-ligating brackets were used which can make a direct comparison difficult; on the other hand both of them presented almost the same prescription and clip property.

Conclusions

The null hypothesis of the present study was mostly accepted which indicated that no significant difference was found between active self-ligating and conventional bracket systems used with different forms of Cu-NiTi archwires regarding mandibular dentoalveolar expansion or incisor proclination. Broad Damon archwires resulted in increased mandibular arch length when compared to standard form archwires in active self-ligating bracket groups.

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Nil.

Conflicts of interest

The authors report no conflicts of interest.

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