

Orthodontic appliance preferences of children and adolescents

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Introduction: Although attractiveness and acceptability of orthodontic appliances have been rated by adults for themselves and for adolescents, children and adolescents have not provided any substantial data. The objective of this study was to evaluate preferences and acceptability of orthodontic appliances in children and adolescents. **Methods:** Images of orthodontic appliances previously captured and standardized were selected and incorporated into a computer-based survey. Additional images of shaped brackets and colored elastomeric ties, as well as discolored clear elastomeric ties, were captured and incorporated onto existing survey images with Photoshop (Adobe, San Jose, Calif). The survey displayed 12 orthodontic appliance variations to 139 children in 3 age groups: 9 to 11 years ($n = 45$), 12 to 14 years ($n = 49$), and 15 to 17 years ($n = 45$). The subjects rated each image for attractiveness and acceptability. All images were displayed and rated twice to assess rater reliability. **Results:** Overall reliability ratings were $r = 0.74$ for attractiveness and $k = 0.66$ for acceptability. There were significant differences in bracket attractiveness and acceptability in each age group. The highest-rated appliances were clear aligners, twin brackets with colored ties, and shaped brackets with and without colored ties. Colored elastomeric ties improved attractiveness significantly over brackets without colored ties for children in the 12-to-14 year group. There was a tendency for older subjects to rate clear orthodontic appliances higher than did younger subjects. Ceramic brackets with discolored ties tended to be rated lower than ceramic brackets with new ties and scored lowest in acceptability and attractiveness in all age groups. Girls rated shaped brackets significantly higher than did boys. **Conclusions:** Children's preferences for orthodontic appliances differ by age and sex. Child and adolescent preferences differ from adult preferences. (Am J Orthod Dentofacial Orthop 2010;138:698.e1-698.e12)

Traditionally, the options for bracket style or appliance design were considerably limited for both the patient and the provider. Recently, the orthodontic market has experienced phenomenal growth in the development and production of orthodontic appliances that are designed to appeal to the patient consumer. A shifting paradigm toward dental esthetics,¹ increased demand for orthodontic treatment,² consumer-driven desire for esthetic treatment alternatives, and a competitive

orthodontic industry and specialty have all contributed to the development and production of alternative orthodontic appliances and new bracket styles.^{3,4} Orthodontic patients and practitioners now have a variety of treatment options previously unavailable.

Orthodontic appliances have evolved according to public demand and available technology, with the underlying goal, in large part, to reduce the visibility of the appliances.³ With the development of successful direct bonding techniques, the use of custom-fitted bands was replaced by bondable brackets. Plastic and ceramic brackets were developed to provide a relatively clear and esthetic alternative to metal braces,⁴ but they also introduced greater complications with bonding and breakage, decreased treatment efficiency, and increased costs to the patient and the provider.⁵⁻⁷ Clear plastic tray aligners (eg, Invisalign, Align Technology, Santa Clara, Calif) and lingual braces were developed to provide even more invisible options for patients, but they have unique clinical obstacles and treatment limitations.⁸⁻¹²

Some advances in appliance design, however, have moved against the trend for clear or invisible appliances. Elastomeric ligature ties, for the most part, have replaced steel ligature ties as a means of engaging

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The authors report no commercial, proprietary, or financial interest in the products or companies described in this article.

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Submitted, March 2010; revised and accepted, June 2010.

0889-5406/\$36.00

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doi:10.1016/j.ajodo.2010.06.012

archwires and introduced a variety of colors for patients to select. Companies such as WildSmiles (WildSmiles, Omaha, Neb) incorporated unique and eye-catching shapes into the base of traditional twin brackets, allowing patients to select from heart, star, soccer ball, football, or diamond shaped braces.

Just as each orthodontic appliance is unique in its esthetic qualities, each also has biomechanical benefits and potential limitations. For a practitioner providing bracket options for patients, selecting which bracket to offer becomes a function of both esthetics and functionality: what will be esthetically acceptable to the patient and clinically efficient for the doctor?

Few studies have investigated patients' perceptions of appliance esthetics. Ziuchkovski et al¹³ evaluated the attractiveness and acceptability of traditional, ceramic, self-ligating, and lingual braces, as well as clear aligners for adults and their children. Rosvall et al¹⁴ evaluated an expanded set of bracket options and included an assessment of the value of esthetic appliances to consumers. Both studies found that attractiveness and acceptability varied significantly by appliance type: alternative appliances (lingual and clear aligners) >ceramic brackets >ceramic self-ligating brackets >all stainless steel twin and self-ligating brackets. They found no statistical significance between the various brands or styles in each category. These studies showed that adult consumers value less metal showing in their braces and were less willing to accept treatment with appliances they consider to be unesthetic.

Although these earlier studies gave a baseline of esthetic values for adult patients, they only indirectly answered how appliance esthetics apply to children.^{13,14} When adult subjects were asked whether the appliances would be acceptable for their child's orthodontic treatment, Ziuchkovski et al¹³ found that all appliances that were rated less acceptable by adults were rated significantly higher in reference to their children. Rosvall et al,¹⁴ however, found no difference in how adult patients rated appliance acceptability for themselves or their children. In a survey of 160 orthodontically treated and untreated 27-year-old Swedish adults, 84% responded that they did, or would have been willing to, wear visible braces during adolescence if needed.¹⁰ When this same group was asked whether they would be willing to wear visible braces as adults, 77% of previously untreated subjects responded definitely or probably, compared with only 60% of those who had undergone previous orthodontic treatment. This suggested that children would be more willing to accept treatment with visible appliances than adults. At this point, no one has asked children and adolescents what they favor for orthodontic appliances and their esthetics. Such studies

have been performed to evaluate adult preferences, but understanding the esthetic desires of the entire patient base requires further investigation of the preferences of children and adolescents.^{13,14}

The purpose of this study was to determine how children perceive the esthetic attractiveness and acceptability of a variety of orthodontic appliances. We evaluated the overall preferences of children and compared the interaction of preferences at different ages and between the sexes. This information will help practitioners recognize and meet the demands of young patients in their practices and provide a baseline of data to be used to assess future changes in patient preferences.

MATERIAL AND METHODS

This research was designed as a computer-based survey, incorporating standardized digital images of orthodontic appliances to evaluate the esthetic preferences of children and adolescents. It was an extension of research projects previously performed by Ziuchkovski et al¹³ and Rosvall et al,¹⁴ and we used some of their previously acquired and standardized images. Research design and survey presentation was the same as used in these previous studies to maintain uniformity and allow a more accurate comparison of results. New variables studied in this project (colored elastomeric ties, shaped brackets, and discolored clear elastomeric ties) were digitally incorporated onto existing images acquired previously to limit confounding variables. A summary of the initial capture and manipulation of these is outlined below. For more details on the methods of image acquisition and standardization, readers are referred to the original articles.^{13,14}

A model was selected for placement and imaging of orthodontic appliances on the basis of good alignment of teeth and the absence of strong sex markers in the circum-oral region. Fabrication of a custom jig specific to the model's dentition allowed for precise and reproducible placement of various bracket systems. Brackets were bonded from maxillary second molar to second molar, and a 14-mil Sentalloy nickel-titanium wire (GAC International, Bohemia, NY) was engaged in with AlastiK clear ligatures (3M Unitek, St Paul, Minn). An Essix (Raintree Essix, Metairie, La) appliance (clear tray) was fabricated and imaged to simulate clear tray alignment systems such as Invisalign.

Images were captured with a digital camera (D100, Nikon, Melville, NY) equipped with a Nikko 24 to 85-mm macro lens and Nikon SB-29s Macro Speedlight flash. Camera settings were manually set, and all in-camera image enhancement features were turned off. A custom jig was used for image acquisition to

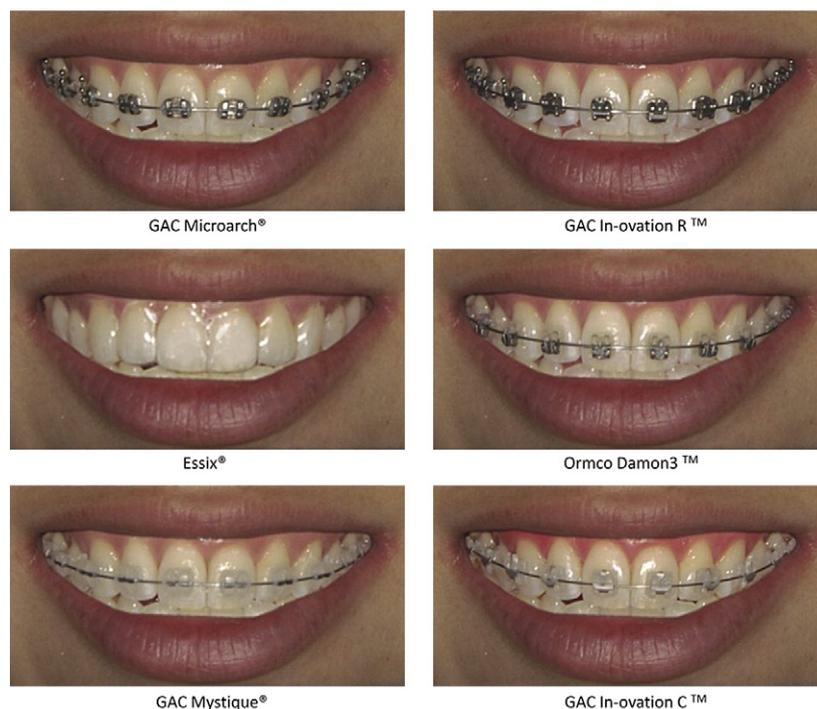


Fig 1. Images acquired and standardized in previous studies.

standardize the camera distance and angle. Lighting conditions were constant for all images acquired, and a GretagMacbeth Mini ColorChecker (X-Rite, Grand Rapids, Mich) was fastened to the jig to allow for standardization of images to the standard color reference patches.

Image incorporation and standardization was performed with Photoshop (version 7.0, Adobe, San Jose, Calif), and the inCamera plug-in software (version 4.0.1, Pictocolor Software, Burnsville, Minn). To limit confounding variables, a standard perioral smiling image of the model was captured and layered over intraoral appliance images. Appliance image position in reference to the smile layer was standardized by means of vertical and horizontal reference lines and verified by toggling between intraoral layers in Photoshop. Examples of several images acquired by this method are shown in Figure 1.

Shaped brackets were supplied by WildSmiles and incorporated onto existing images. WildSmiles star and heart shaped brackets were selected to represent the bracket styles most appealing to male and female subjects. The brackets were mounted on a typodont model from maxillary canine to canine in the proper mesiodistal and incisal-gingival position. A 14-mil Sentalloy nickel-titanium wire was engaged with clear elastomeric ties. Images of the brackets were captured

by using a digital camera (D60, Nikon) with standard flash and a Nikkor 18 to 55 mm lens. By using Photoshop Elements 7.0, WildSmiles brackets and ligature ties were individually cut and layered over an existing image at corresponding maxillary canine-to-canine brackets. Bracket brightness, contrast, hue, and saturation were adjusted to match adjacent brackets. **Examples of the WildSmiles images are shown in Figure 2.**

Clear elastomeric ties on existing survey images were digitally enhanced to simulate colored elastomeric ties. Individual ties were traced and layered in Photoshop 7.0 on MicroArch (GAC International) and WildSmiles bracket images. The hue, saturation, and lightness of the elastomeric ties were adjusted to create accurate representations of red, dark red, green, orange, blue, light blue, pink, purple, violet, and gray ties. These colors were used to show the possible color options that patients could choose at appointments. Care was taken to record the level and degree of color enhancement to standardize colors between bracket images. Examples of colored elastomeric ties are displayed in Figure 3.

Similar techniques were used to simulate the discoloration of clear elastomeric ties that typically occurs between appointments. Before image enhancement, digital photos were taken of several patients with ceramic brackets and clear elastomeric ties after 4 to 6 weeks of placement and used to reference the



Fig 2. Images of WildSmiles shaped brackets.



Fig 3. Image of MicroArch brackets with colored elastomeric ties.

discoloration typically seen at adjustment appointments. By using Photoshop, clear elastomeric ties on Mystique brackets (GAC International) were then discolored (yellowed and darkened) according to actual patient images. An example of these brackets is given in Figure 4.

Previous research showed no significant difference between how adult subjects rated 3 ceramic brackets: Mystique, Ice (Ormco, Orange, Calif), and Clarity (3M Unitek).^{13,14} Because Mystique had the highest average visual analog score (VAS) in previous research, it was selected to represent ceramic brackets in this survey.¹⁴ There was also no significant difference in previous studies between the control (representing lingual braces) and the Essix (representing Invisalign).^{13,14} Because it could be confusing for children to rate an orthodontic appliance that they could not see, we eliminated the image of lingual braces from this survey. Table I details the appliances and ligature tie combinations used in this study.

Acquired and standardized images were incorporated into a computer-based survey and administered to children and adolescents 9 to 17 years old. The survey was designed and prepared by using a numerical computing environment and programming language software (MATLAB R2008a, Mathworks, Natick, Mass). A customized mouse-operated graphic interface was developed that combined data collection and survey

administration. Images were displayed on a laptop computer (Pavilion dv6000, Hewlett Packard, Palo Alto, Calif) with a 17-in monitor at a life-size ratio to allow a realistic assessment of bracket esthetics.

The study was approved by the institutional review board of The Ohio State University. The subjects were recruited in the College of Dentistry clinics. Eligibility to participate in the survey included any willing child 9 to 17 years old who had never undergone orthodontic treatment with brackets or aligners. All surveys were completed on a laptop computer in the consultation rooms of the orthodontic clinic. The computer survey included an introduction, demographic information, instructions, and image rating screens. Subjects navigated through the survey by clicking “next” and were prevented from proceeding if all questions were not completely answered.

A series of tutorial screens instructed subjects on how to complete the survey and gave examples of orthodontic appliances to be rated. The subjects were instructed on how to use the VAS on a sample survey question and could practice using the scale by clicking or dragging the VAS marker. As an example of colored elastomeric ties, the subjects were shown a full smiling image of MicroArch brackets with red ties, displayed over a series of 9 variously colored elastomeric ties on single brackets. The subjects were told that these images represented their ability to select various colored ties at each orthodontic visit. The subjects were also briefly introduced to clear tray aligners and shown an image of an Essix appliance. At the conclusion of the instructional pages, the subjects were presented a grid of all 12 appliance images and instructed to take a minute to look at all images before starting the survey. By doing so, the subjects could familiarize themselves with all appliances before rating the first image displayed.

The image-rating pages consisted of a VAS question and a yes-or-no acceptability question. The subjects were presented the image to be rated and were asked, “how good do you think these braces look?” Attractiveness was gauged by means of the VAS, a horizontal bar anchored by “really good” on 1 side and “really bad”



Fig 4. Clear elastomeric ties and discolored clear elastomeric ties on Mystique brackets.

Table I. List of appliance images and classification

Appliance/tie combination	Type of appliance
GAC MicroArch, clear ties	Standard twin stainless steel
GAC MicroArch, colored ties	Standard twin stainless steel
WildSmiles hearts, clear ties	Stainless steel shaped
WildSmiles hearts, colored ties	Stainless steel shaped
WildSmiles stars, clear ties	Stainless steel shaped
WildSmiles stars, colored ties	Stainless steel shaped
GAC In-Ovation R	Stainless steel self-ligating
Ormco Damon 3	Hybrid self-ligating
GAC In-Ovation C	Ceramic self-ligating
GAC Mystique, clear ties	Ceramic
GAC Mystique, discolored ties	Ceramic
Essix (clear tray)	Clear tray aligner

on the other. A thin gray marker in the middle of the bar could be dragged to the desired spot along the scale, or the subject could simply click anywhere along the bar to move the marker to that point. The subjects were then asked the acceptability question, “if you were going to have braces, would you be willing to wear these?” All orthodontic appliance images were displayed in random order. After each image had been displayed and rated once, all images were randomly displayed again, and the same questions were asked to evaluate intrarater reliability.

The final survey page displayed a grid of all 12 appliance images. The subjects were asked, “if you were going to have braces, which appliance style would you prefer most? Click on the picture of your favorite style; then click on your second favorite, third, fourth, and fifth.” While seeing all appliance options, the subjects could then rank their 5 favorite brackets.

The sample size was based on a power analysis with results from previous studies.^{13,14} The results of this analysis showed that a sample of 45 subjects in each age group (9-11, 12-14, and 15-17 years) was needed to detect statistical significance with a power of 0.8 and an alpha of 0.05. This allowed pair-wise comparisons between the 3 groups and potentially detected differences as small as 12% on the VAS scale.

One hundred forty-one subjects attempted to take the survey. One subject chose not to complete it after starting, and another was unable to complete the survey without help from a family member. The remaining subjects (n = 139) are detailed by their demographic groupings in Table II.

Statistical analysis

Each image used in the survey was rated twice to assess intrarater reliability. All VAS and acceptability values used for statistical analyses were averages of both ratings. For acceptability, recorded as either 0 or 1, this produced a value of 0.5 if the subject rated the appliance acceptable 1 time and unacceptable another time. These responses represented a borderline acceptable bracket.

In the survey, 2 bracket shapes were used to represent WildSmile braces. The intent of using various WildSmiles brackets in the study was not to determine a ranking or preference between shaped bracket styles, but to determine how shaped brackets in general rated against other common appliances. Therefore, for each subject, the WildSmiles bracket (heart or star) rated highest according to the VAS was used to represent the rater’s preference for shaped brackets. The other bracket was eliminated from statistical analyses comparing WildSmiles with other appliances. This was done for both colored and clear elastomeric ties.

The final rating page or rank list, where subjects were instructed to rank their 5 favorite appliances, was used as a second measure to validate the attractiveness and acceptability results. Because the subject was selecting between 12 appliance options, a 12-point scale was used to objectively evaluate overall brackets preferences. Appliances selected first were assigned 12 points; those selected second, 11 points; those selected third, 10 points; and so on. Any appliance that was not selected in the subject’s top 5 was assigned zero points. Point totals for each bracket were averaged to find the overall preference of brackets in each age group. To compare the effect of colored elastomeric ties on stainless steel brackets, ratings from each

Table II. Demographic summary of research subjects

Demographic category	Response rate per question	Demographic groupings	Count (n)	Relative frequency rate
Sex	100%	Male	58	41.7%
		Female	81	58.3%
Age (y)	100%	Group 1		
		9	5	3.6%
		10	17	12.2%
		11	23	16.5%
		Group 2		
		12	18	12.9%
		13	17	12.2%
		14	14	10.1%
		Group 3		
		15	24	17.3%
16	12	8.6%		
17	9	6.5%		

colored bracket option (MicroArch, WildSmiles stars, and WildSmiles hearts) were combined in each age group to compare with the noncolor bracket counterpart.

Intrarater reliability for the attractiveness study was evaluated by the Strout Fleiss intraclass correlation coefficient. Reliability of yes-or-no responses for acceptability was assessed with the kappa statistic. VAS ratings were analyzed by using a factorial analysis of variance (ANOVA) with repeated measures. Mean scores of VAS ratings were adjusted by using the least squares means method. Because each image was rated more than once, acceptability values were converted to relative frequency of response and statistically analyzed the same as VAS ratings. The Bonferroni adjustment was applied for multiple comparisons (overall $\alpha < 0.05$). Statistical analyses were calculated with SAS software (version 9.2, SAS, Cary, NC).

RESULTS

Results for appliance attractiveness and acceptability are presented in Figures 5 through 9. Higher VAS scores (scored 0-100) and higher acceptability scores (scored 0-1) indicate greater appliance attractiveness and acceptability. Significant interactions were found between age group by bracket and sex by bracket.

Each image was rated twice for attractiveness and acceptability to assess intrarater reliability. Overall reliability ratings were $r = 0.74$ for attractiveness and $k = 0.66$ for acceptability.

For group 1 (ages 9-11 years), the least squares mean VAS scores for each appliance are displayed in Figure 5, A. The highest-rated and statistically similar appliances were MicroArch with colored ties, WildSmiles

with colored ties, Invisalign, WildSmiles, and MicroArch. MicroArch with colored ties, WildSmiles with colored ties, and clear aligners were statistically more attractive than all complete or partially ceramic brackets.

For group 2 (ages 12-14 years), the least squares mean VAS scores for each appliance are displayed in Figure 5, B. The highest-rated and statistically similar appliances were the same as those in group 1: MicroArch with colored ties, Invisalign, WildSmiles with colored ties, WildSmiles, and MicroArch. MicroArch with colored ties and Invisalign were rated significantly more attractive than all ceramic and hybrid brackets.

For group 3 (ages 15-17 years), the least squares mean VAS scores for each appliance are displayed in Figure 5, C. Clear tray aligners were rated significantly more attractive than all other appliances rated. The order of preference for the remaining appliances was different from previous age groups, but the differences were not statistically significant. The pooled attractiveness results for all subjects are displayed in Figure 6, A. Two comparisons were statistically significant. **Girls rated the attractiveness of WildSmiles brackets significantly higher than did the boys, whereas boys rated the attractiveness of Mystique brackets with discolored ties significantly higher than did the girls.**

Pooled VAS averages for brackets with colored elastomeric ties vs clear elastomeric ties are displayed in Figure 7. With each age group, colored elastomeric ties rated higher than their noncolored counterparts, but this difference was statistically significant only in the second age group.

Acceptability rates for each appliance by age group and sex are presented in Figure 8. In the youngest age group, MicroArch brackets with colored ties were rated the most acceptable at 92%, significantly higher than all ceramic and hybrid appliances. MicroArch brackets with colored ties were also rated the highest in the second age group at 89%, significantly higher than all ceramic, hybrid, and self-ligating appliances. In the oldest age group, clear tray aligners were rated most acceptable at 91%, significantly higher than all ceramic, hybrid, self-ligating, and shaped brackets. Comparisons between the sexes showed higher acceptability for shaped brackets by girls (Fig 6, B).

Pooled averages for appliances ranked 1 through 5 are displayed in Figure 9. On average, appliance preferences scored according to the ranking system matched the VAS results from the attractiveness study in each age group.

DISCUSSION

Previous studies looking at similar variables in adult subjects reported the following hierarchy of appliance

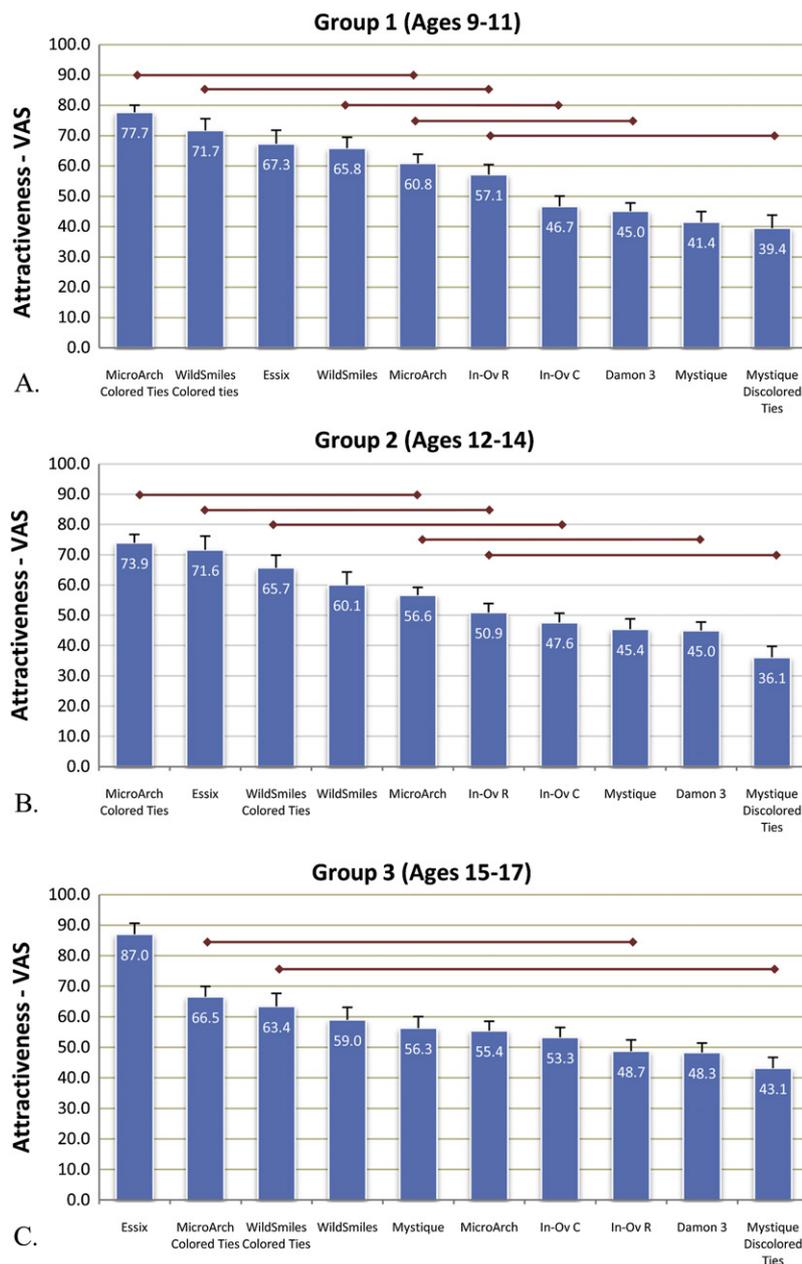


Fig 5. Average VAS ratings for attractiveness: **A**, age group 1; **B**, age group 2; **C**, age group 3. Appliances connected with *overlying bars* denote no difference in statistical significance at $P < 0.05$.

preferences: alternative appliances (clear aligners and lingual brackets) >ceramic appliances >ceramic self-ligating >all hybrid and stainless steel appliances.^{13,14} The authors concluded that patients prefer appliances with less metal showing. This study, however, showed substantial differences in how children’s and adolescents’ preferences for orthodontic appliances differ from each other at various ages and from adults in general. Although we looked at the effect of

additional variables not previously studied in the adult samples, even the variables that were the same in each study showed marked differences. For example, MicroArch, which was rated significantly lower than all ceramic appliances in the research of Ziuchkovski et al,¹³ rated significantly higher than ceramic brackets in the youngest age group in this study and showed a similar trend in the second age group. With the exception of clear tray aligners, in each age group, 3 of the 4 top-rated

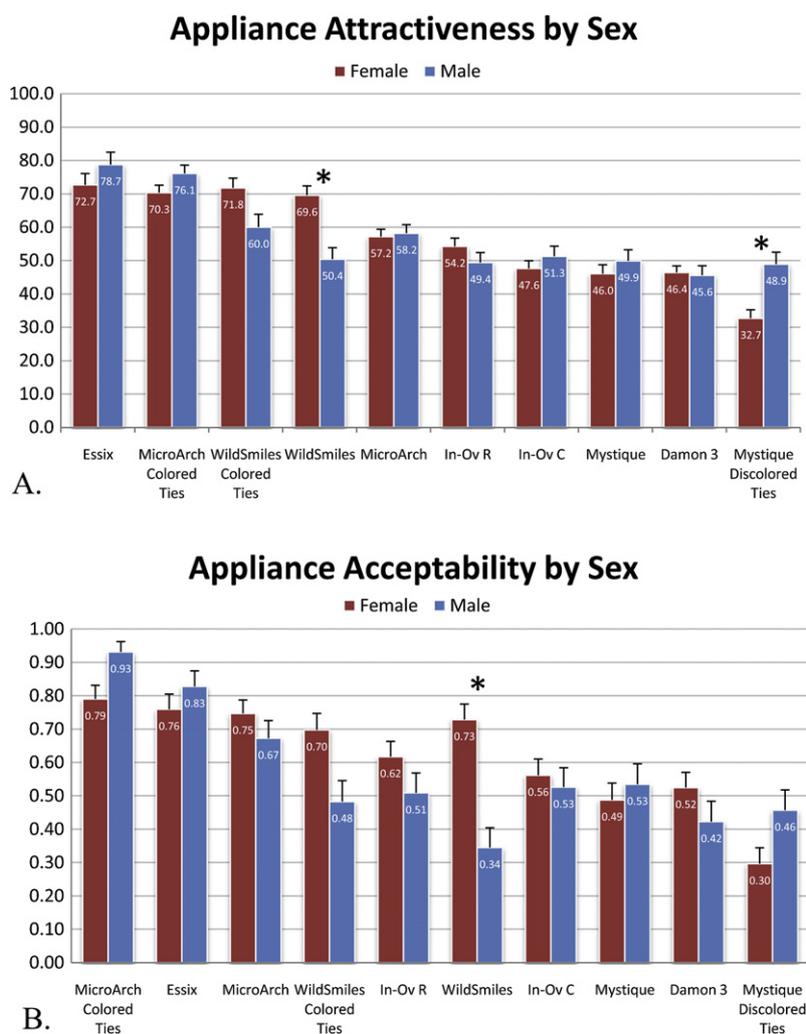


Fig 6. A, Average attractiveness ratings for appliances by sex; **B,** average acceptability ratings for appliances by sex. Comparisons designated with an asterisk were statistically significant at $P < 0.05$.

appliances were all-metal brackets. Consequently, ceramic and hybrid brackets comprised the bottom 4 appliance preferences in the 2 younger age groups. **These data make it apparent that reducing metal show in appliances is not the driving factor for esthetics among most children and adolescents.**

Differences in appliance preference were also apparent between age groups. Although differences in individual bracket scores between the age groups were not statistically significant, the following trends were clear. Older subjects have a greater preference for clear appliances than younger subjects. For the 2 youngest groups, all ceramic and hybrid brackets were rated significantly lower than the highest-rated bracket, MicroArch with colored ties. Attractiveness scores for ceramic and hybrid brackets appliances increased in the oldest group and no longer showed a statistical

difference from standard twin brackets. Although rated relatively high in the first 2 age groups, clear aligners are not rated significantly higher than other top brackets choices. However, in the oldest group, clear aligners were preferred significantly over all other brackets. When looking at each appliance individually, in all appliances but one, metal bracket ratings decreased as age increased, whereas ceramic and plastic appliance ratings increased as age increased. The exception to this rule was the Mystique bracket with discolored ties, which was rated consistently lowest in all age groups. These trends show the general evolution of preferences for the maturing adolescent and begin to resemble the findings of previous adult-based studies.

Acceptability scores generally mimic the VAS rankings in each age group, with some notable exceptions. Traditional twin brackets (MicroArch) without colored

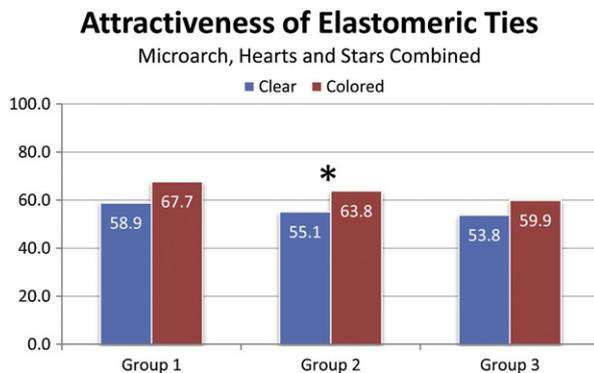


Fig 7. Average VAS ratings of MicroArch, WildSmiles stars, and WildSmiles hearts brackets with colored or clear elastomeric ties. Comparisons designated with an asterisk were statistically significant at $P < 0.05$.

elastomeric ties ranked fourth or fifth in attractiveness against all other appliances in each age group. However, for acceptability, these same brackets were rated second most acceptable among the first 2 age groups and third most acceptable in the third age group. This suggests that, although the bracket might not be considered particularly esthetic, it is generally accepted by most patients. Conversely, shaped brackets (WildSmiles), which maintained high attractiveness ratings among all age groups, were rated lower with regard to acceptability. This suggests that many subjects found them to be esthetic, but some would not be willing to wear them as part of their treatment.

The ability to select colored elastomeric ties had a significant effect upon the attractiveness of metal brackets. This preference for colored ties was observed in each age group with each colored and noncolored bracket pair. When all 3 colored bracket options were combined in each age group, this preference for colored ties showed a significant difference in the second age group and neared significance in the first. Since colored ties were not rated in previous studies, no comparison can be made with the preference for colored ties in adult subjects.

Discolored clear elastomeric ties were included in this study to determine whether the discoloring effect of clear ties would significantly decrease the attractiveness and acceptability of ceramic brackets over self-ligating ceramic brackets and other appliances. Although not statistically significant, brackets with discolored ties were rated consistently lower than ceramic brackets with new ties and lowest of all appliances in each age group.

The rank list at the end of the survey asked subjects to rank their 5 favorite appliances from all appliances

displayed. Presumably, this second method of evaluating appliances could serve to validate the attractiveness and acceptability results of the study. As these rankings were pooled and objectively scored, the cumulative appliance preferences based on subject rankings validated and supported the rankings obtained from the VAS results for each age group. Some discrepancies were noted, however, when each subject's highest-ranked appliance was compared against the appliance he or she rated highest according to the VAS. In total, 70% of the subjects selected as their number 1 preference the same appliance type that they rated highest in attractiveness. Interestingly, in the first 2 age groups, the appliance selected most frequently as the number 1 choice was some variation of WildSmiles brackets at 44%. The most frequently selected number 1 appliance in the oldest age group was clear tray aligners at 53%.

The findings of this study have direct clinical implications for practicing orthodontists. Orthodontists must select between available appliances to provide brackets that are acceptable to patients and work in harmony with their biomechanical philosophy. Since children and adolescents continue to make up the vast majority of orthodontic patients, understanding which appliances are acceptable to them will help practitioners meet their needs. It might be reassuring to practitioners that standard stainless steel twin brackets with colored ties, typically the least expensive bracket option and the most frequently used by orthodontists,¹⁵ were rated highest in attractiveness and acceptability among children aged 9 to 14 and second highest by those aged 15 to 17. By providing these brackets, doctors can cater to the desires of over 85% of their patients.

Children and adolescents also showed a high preference for clear tray aligners. For both attractiveness and acceptability, clear aligners ranked high in the younger groups and highest in the oldest group. However, despite the overall high rating for these appliances, their practical use is somewhat limited in children and adolescents. Since its inception in 1999, Invisalign treatment has typically been reserved for comprehensive adult dentition cases. In recent years, however, Align Technology has attempted to answer the apparent demand among nonadult patients with the release of Invisalign Teen. Although Invisalign Teen can provide a valid appliance option for some adolescents, most children, especially those in the mixed dentition, might not be suitable for treatment with this technology.

Another recent movement in orthodontics has been the rapid increase in the number of doctors using self-ligating bracket systems. The use of self-ligating brackets in orthodontic offices has risen from 9.8% in 2002 to 38.2% in 2008.¹⁵ Biomechanically and

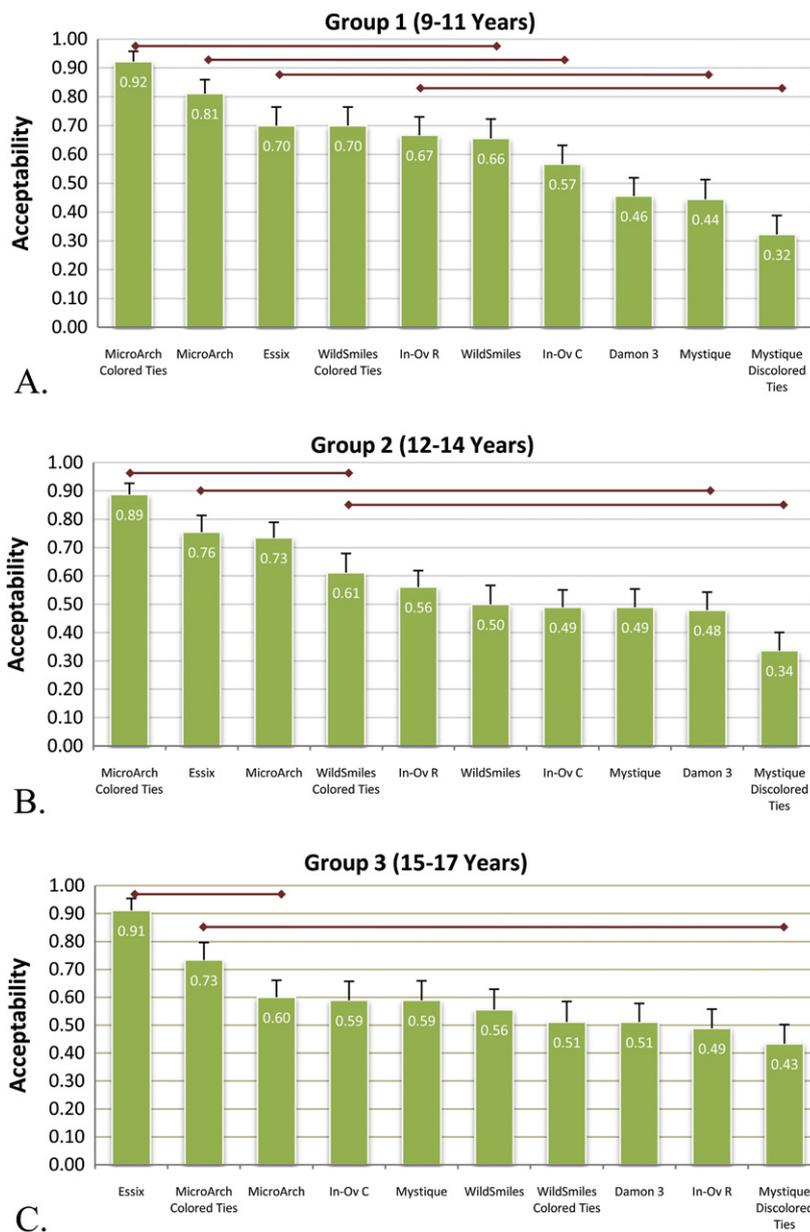


Fig 8. Average acceptability ratings by group: **A**, age group 1; **B**, age group 2; **C**, age group 3. Appliances connected with *overlying bars* denote no difference in statistical significance at $P < 0.05$.

clinically, many advantages over traditional brackets have been claimed, including more rapid and efficient tooth movement,¹⁶ reduced friction,¹⁷ greater comfort,¹⁸ faster wire changes,¹⁹ and reduced overall treatment times.^{16,20} It appears, however, that these proposed advantages come at a cost to patient esthetics. Among children aged 9 to 14, all self-ligating systems were considered significantly less attractive than traditional twin brackets with colored elastomeric ties. Furthermore, in all age groups, acceptability rates for any self-ligating bracket were

23% to 46% lower than traditional twin brackets with colored elastomeric ties. For some patients, the inability to select colors at each appointment might become an obstacle to accepting treatment with a self-ligating bracket. Although colored ties could be added to self-ligating brackets, many potential benefits would then be negated. In this study, 3 self-ligating brackets were selected, but, because there are many variations in the design of self-ligating brackets, these brackets might not represent all self-ligating systems.

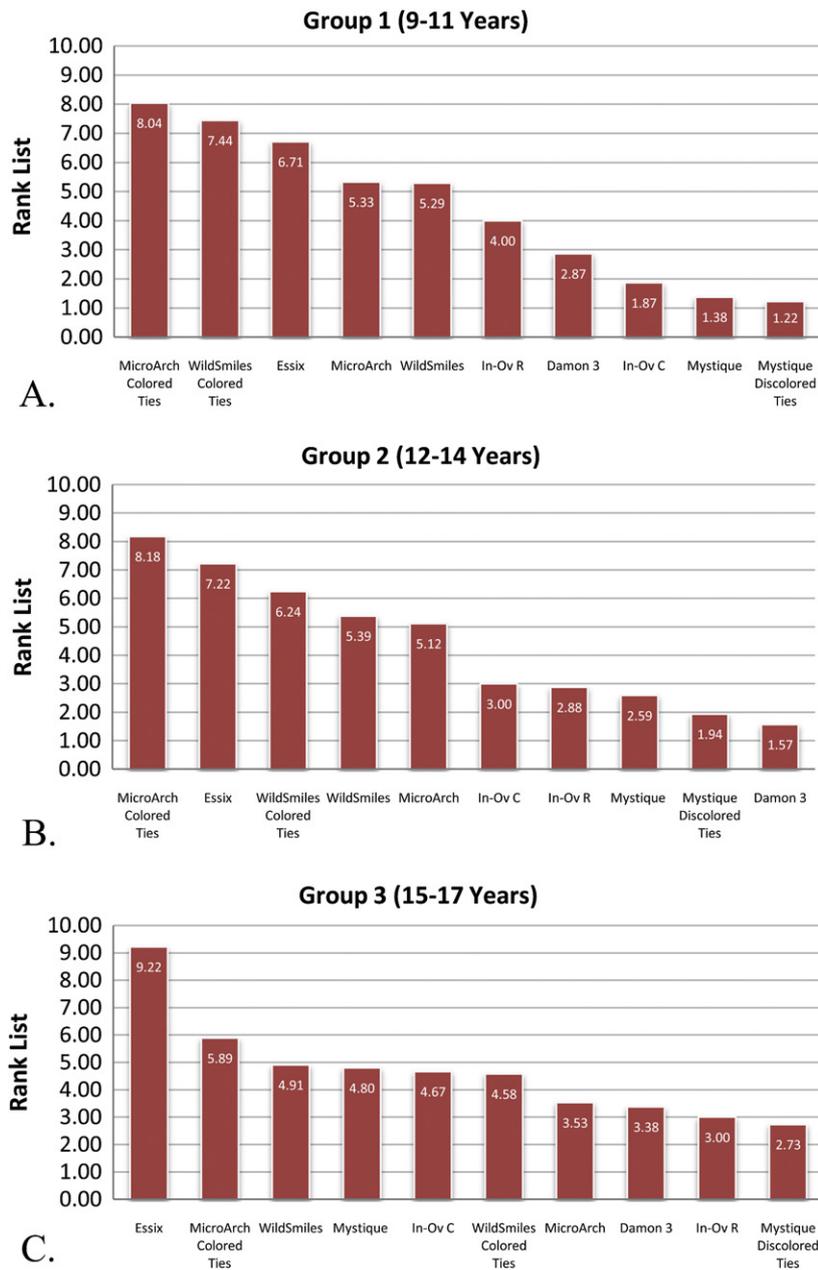


Fig 9. Average rank list scores: **A**, age group 1; **B**, age group 2; **C**, age group 3. Higher average values indicate greater appliance preference.

One surprising finding of this study was the overall high rating of shaped brackets in all age groups. Acceptability for shaped brackets was highest in the youngest group at 70%, 25% higher in acceptability than traditional ceramic brackets. This preference over ceramic brackets diminished in the second age group and appeared to level out in the third age group. This apparent preference for shaped brackets over ceramic brackets, especially in children aged 9 to 14, was also

evident in the subjects' rank lists. Thus, it would appear that, if an orthodontic practice were to offer an alternative bracket to its standard appliance for children and adolescents, WildSmiles would most likely elicit more demand than a ceramic bracket.

New brackets and variations in elastomeric ties were captured separately from the images used in previous studies and incorporated onto existing images by using digital imaging software. Although care was taken to

closely match the optical properties of these appliances and create a realistic representation of these variables, there might have been slight variations in color or quality. Consequently, all digital images displayed in the survey might not exactly represent their actual clinical presentations. However, we believe that these potential minor variations would not significantly impact our findings. Furthermore, the appliances were all displayed on a model with well-aligned teeth. Although this presentation might not represent the clinical appearance of these appliances during the early stages of treatment, well-aligned teeth were used to reduce variables that can distract from the evaluation of appliance esthetics and allow a more accurate comparison with the results of previous studies.

CONCLUSIONS

1. Child and adult preferences for orthodontic appliances differ. Reducing metal show in appliances is not the driving factor for esthetics among most children and adolescents.
2. Children's preferences for orthodontic appliances differ by age and sex. Older children tended to have a stronger preference for clear appliances than younger children. **Shaped brackets were preferred most by younger patients and girls.**
3. Stainless steel brackets with colored ties and clear tray aligners were highly accepted by all age groups.
4. Colored elastomeric ties contribute significantly to the attractiveness of orthodontic appliances for children and adolescents.

We recognize the financial support for this research from the Dental Master's Thesis Award Program sponsored by Delta Dental Foundation, the philanthropic affiliate of Delta Dental of Michigan, Ohio, and Indiana. We also thank WildSmiles for providing the brackets.

REFERENCES

1. Sarver DM, Ackerman JL. Orthodontics about face: the re-emergence of the esthetic paradigm. *Am J Orthod Dentofacial Orthop* 2000;117:575-6.
2. Keim RG, Gottlieb EL, Nelson AH, Vogels DS 3rd. 2007 JCO orthodontic practice study. Part 1: trends. *J Clin Orthod* 2007;41:617-26.
3. Willems G, Carels CE. Developments in fixed orthodontic appliances. *Ned Tijdschr Tandheelkd* 2000;107:155-9.
4. Russell JS. Aesthetic orthodontic brackets. *J Orthod* 2005;32:146-63.
5. Redd TB, Shivapuja PK. Debonding ceramic brackets: effects on enamel. *J Clin Orthod* 1991;25:475-81.
6. Loftus BP, Årtun J, Nicholls JI, Alonzo TA, Stoner JA. Evaluation of friction during sliding tooth movement in various bracket-arch wire combinations. *Am J Orthod Dentofacial Orthop* 1999;116:336-45.
7. Omana HM, Moore RN, Bagby MD. Frictional properties of metal and ceramic brackets. *J Clin Orthod* 1992;26:425-32.
8. Joffe L. Invisalign: early experiences. *J Orthod* 2003;30:348-52.
9. Djeu G, Shelton C, Maganzini A. Outcome assessment of Invisalign and traditional orthodontic treatment compared with the American Board of Orthodontics objective grading system. *Am J Orthod Dentofacial Orthop* 2005;128:292-8.
10. Meier B, Wiemer KB, Miethke RR. Invisalign—patient profiling. Analysis of a prospective survey. *J Orofac Orthop* 2003;64:352-8.
11. Ling PH. Lingual orthodontics: history, misconceptions and clarification. *J Can Dent Assoc* 2005;71:99-102.
12. Poon KC, Taverne AA. Lingual orthodontics: a review of its history. *Aust Orthod J* 1998;15:101-4.
13. Ziuchkovski JP, Fields HW, Johnston WM, Lindsey DT. Assessment of perceived orthodontic appliance attractiveness. *Am J Orthod Dentofacial Orthop* 2008;133(Suppl):S68-78.
14. Rosvall MD, Fields HW, Ziuchkovski J, Rosenstiel SF, Johnston WM. Attractiveness, acceptability, and value of orthodontic appliances. *Am J Orthod Dentofacial Orthop* 2009;135:276.e1-12.
15. Keim RG, Gottlieb EL, Nelson AH, Vogels DS 3rd. 2008 JCO study of orthodontic diagnosis and treatment procedures, part 1: results and trends. *J Clin Orthod* 2008;42:625-40.
16. Harradine NW. Self-ligating brackets and treatment efficiency. *Clin Orthod Res* 2001;4:220-7.
17. Sims AP, Waters NE, Birnie DJ. A comparison of the forces required to produce tooth movement ex vivo through three types of pre-adjusted brackets when subjected to determined tip or torque values. *Br J Orthod* 1994;21:367-73.
18. Shivapuja PK, Berger J. A comparative study of conventional ligation and self-ligation bracket systems. *Am J Orthod Dentofacial Orthop* 1994;106:472-80.
19. Turnbull NR, Birnie DJ. Treatment efficiency of conventional vs self-ligating brackets: effects of archwire size and material. *Am J Orthod Dentofacial Orthop* 2007;131:395-9.
20. Eberting JJ, Straja SR, Tuncay OC. Treatment time, outcome, and patient satisfaction comparisons of Damon and conventional brackets. *Clin Orthod Res* 2001;4:228-34.