

Esthetic perception and economic value of orthodontic appliances by lay Brazilian adults

Daniela Feu¹, Fernanda Catharino², Candice Belchior Duplat³, Jonas Capelli Junior⁴

Objective: To evaluate the esthetic perception of different appliances by Brazilian lay adults and its influence in the attributed value of orthodontic treatment, considering evaluators' socioeconomic status, age and gender.

Methods: Eight different combinations of orthodontic appliances and clear tray aligners were placed in a consenting adult with pleasing smile. Standardized frontal photographs were captured and incorporated into a research album. A sample of adults (n = 252, median = 26 years old) were asked to rate each image for (1) its attractiveness on a visual analog scale and (2) the willingness to pay (WTP) for a cosmetic appliance when compared to a standard metallic appliance and a clear tray aligner. Comparisons between the appliances' attractiveness were performed using the Friedman's test and Dann's post-hoc test. Correlation between appliances' attributed value, socioeconomic status, age, gender, and esthetic perception was assessed using Spearman's correlation analysis.

Results: Attractiveness ratings of orthodontic appliances varied significantly in the following hierarchy: Clear aligners>sapphire brackets>self-ligating/conventional stainless steel brackets>and golden metal appliances. The correlation between WTP and esthetic perception was weak. However, for individuals with better socioeconomic status and aged between 17-26 years old significantly, a significantly higher WTP was found.

Conclusion: Clear aligners and sapphire brackets with esthetic archwire were considered better esthetic options in this sample. Nevertheless, patients were not willing to pay more money for appliances they deemed more esthetic, however, they were significantly influenced by their socioeconomic level and age.

Keywords: Orthodontic appliances. Esthetics. Corrective orthodontic treatment. Cost-benefit analysis.

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» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

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INTRODUCTION

During the past years, orthodontics has greatly evolved regarding esthetic materials. Nowadays, orthodontic brackets are becoming smaller and more discrete; in addition, the esthetic appliances represent an alternative for patients that are reluctant to use metallic appliances. Orthodontic appliances have evolved according to public demand and available technology, especially with the underlying goal of reducing the appliances' visibility.^{1,2} The esthetic paradigm shift in dentistry, especially in orthodontics, has shown the urgency to incorporate esthetics to the functional goals and requirements of the orthodontic treatment,² leading to an increase in the demand for orthodontic appliances even more inconspicuous. Therefore, this demand has been primarily driven by the consumers' desire for esthetic alternatives and the competitiveness of the orthodontic industry and specialty.³

Innovations in the aesthetics of orthodontic appliances may also be a major factor in the increase in adult patients' acceptability to orthodontic treatment. Patients considering to undergo orthodontic treatment now have can choose from different appliances currently available, including conventional stainless-steel, ceramic, lingual and clear plastic aligners.¹ Even though orthodontists can use these resources to increase patients' acceptability to orthodontic treatment, few studies have evaluated the attributed value of orthodontic appliances.⁴

A previous study assessing perceived orthodontic appliance attractiveness indicated that adult patients prefer less metal showing in their orthodontic appliances and were less willing to accept treatment with appliances they consider to be unesthetic.^{3,4} In the same way, another study revealed that 67% of Sweden young adults would probably not or definitely not wear visible appliances in spite of a functional treatment indication; and there was also a rejection rate of 33% to conventional orthodontic treatment.⁵ Another aspect is the social perceptions of adults wearing orthodontic appliances, since the judgments concerning their personal characteristics are influenced by dental appearance and orthodontic appliance design.⁶

Just as a variety of social, cultural, psychological and personal factors influence the self-perception of dental appearance and the decision to undergo

orthodontic treatment,^{7,8,9} these factors may also exert an important influence in the perception and acceptability of different orthodontic appliances, indicating that, different populations should be investigated. Understanding the factors involved in the perception of different orthodontic appliances in a particular population enables a better planning of resources and strategies in the private practice, since the appearance of orthodontic appliances plays a significant role in patients' decisions to undergo orthodontic therapy.⁴

The preferences for appliances can also be evaluated in terms of their attributed value to patients.^{10,11} The employment of the willingness-to-pay (WTP) assessment technique has been increasing in different areas, allowing to estimate the attributed value of the health care technologies.¹¹ It is a way of measuring value in monetary terms by a cost-benefit analysis once it assigns monetary values to both costs and outcomes of health care and calculates the net benefit. WTP allows a monetary rating to be attributed to novel health care interventions or outcomes by asking people how much they would pay to obtain the benefits of a specific treatment. This value is set as raters are asked to respond to a hypothetical, conditional question - e.g., "what is the maximum amount you would be willing to pay to access a new intervention, existing the need to undergo treatment?" Such a question is intended to elicit a monetary valuation of the merit, worth or benefit which each subject associates with the specific intervention under consideration. Although the same general question is asked any WTP study, the question can be asked in various formats to adapt to the study.¹² When applied to orthodontics, this method may provide a way to determine the value of different appliances for patients of different ages and sociocultural realities.³

The purpose of this study was to evaluate the esthetic perception of lay Brazilian adults on different orthodontic appliances designs and its influence in the attributed value of orthodontic treatment, considering raters' socioeconomic status, age and gender.

MATERIAL AND METHODS

This research was approved by the ethics research committee of Rio de Janeiro State University where this study was performed.

An adult volunteer was selected for receiving the appliances and pictures capturing. Selection criteria were: Well aligned teeth, proper gingival and incisor display and the absence of strong gender markers in the circum-oral region. The volunteer was also asked to sign de informed consent. Digital image capture was made in frontal view with an SLR camera (EOS Rebel T1, Canon, Oita, Japan) equipped with a 100 mm macro lens (Macro Lens EF 100 mm, Canon, Oita, Japan) and a ring flash (Macro Ring Light MR-14ex, Canon, Oita, Japan). Traditional metal brackets (Masel, California, USA), self-ligated metal brackets (Tellus, Eurodonto, Brazil), golden metal brackets (GAC International, New York, USA) and sapphire esthetic orthodontic brackets (Radiance, American Orthodontics, Wisconsin, USA) were temporarily bonded to the dental surfaces of the maxillary arch without acid etching. For the simulated bonding of the appliances, Transbond XT (3M Unitek, California, USA) adhesive was used. A 0.020-in stainless steel archwire (GAC International, New York, USA) was used as reference for brackets positioning, allowing reproducibility for placement of various bracket systems. Brackets were bonded from upper right second molar to upper left second molar. A clear tray was fabricated and imaged to simulate clear tray alignment systems such as Invisalign (Invisalign, Align Technology, California, USA). Two trays were produced: One simulating attachments in front teeth (12 and 22 in vestibular side) and one with no attachments. Attachments were transparent, rounded, and had approximately a three millimeters radius.

Camera settings were manually set, and all in-camera image enhancement features were turned off to ensure images' reproducibility. Lighting conditions were constant for all images acquired.

All photographs of the volunteer's smile were performed in the natural head position, with the aid of the cephalostat of the UERJ Dental Radiology Clinics, thus ensuring the correct positioning of the head. The ear positioners restricted excessive lateral movement while the nasion positioner limited vertical movements. (Fig 1). The camera was attached to a tripod and positioned at a fixed distance of 110 cm in a straight line between the patient's face and the camera lens.

Photos of the volunteer's smile were obtained in eight different situations: (1) With clear tray and attachments, (2) with clear tray without attachments; (3) with fixed traditional metallic brackets using gray elastomeric ligatures and (4) green elastomeric ligatures (Morelli, São Paulo, Brazil), (5) with fixed metallic self-ligated brackets; (6) with fixed golden orthodontic brackets and clear elastomeric ligatures (American Orthodontics, Wisconsin, USA); (7) with fixed esthetic brackets, clear elastomeric ligatures (American Orthodontics, Wisconsin, USA) and 0.020-in stainless steel archwire (GAC International, New York, USA), as in all previous described situations, and (8) with fixed esthetic brackets, clear elastomeric ligatures (American Orthodontics, Wisconsin, USA) and 0.018-in esthetic nickel titanium coated archwire (American Orthodontics, Wisconsin, USA). Image incorporation and standardization was performed with Photoshop (version 9.0, Adobe, California, USA).

The photo album was composed of three sheets of photo-quality color prints. Each sheet had 29.7 cm x 21 cm. The first sheet comprised eight images, with all compositions of orthodontic appliances described

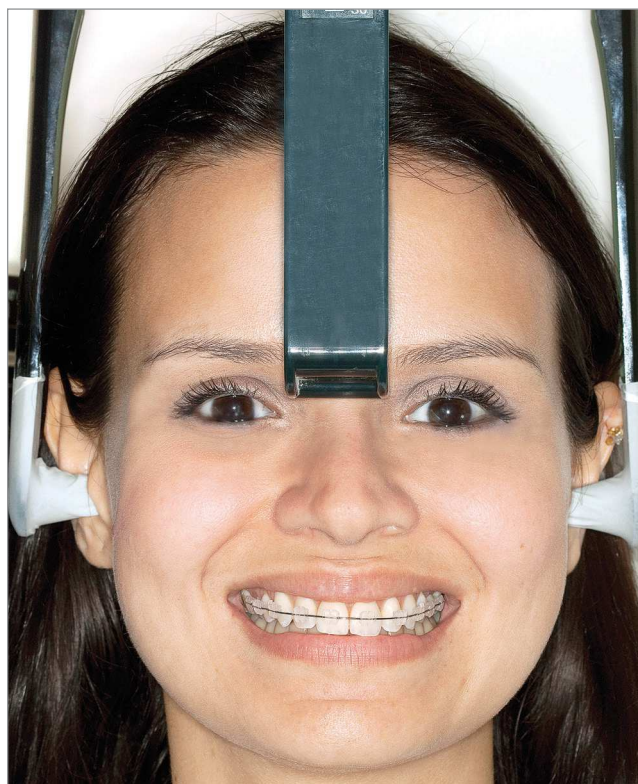


Figure 1 - Volunteer positioned in the cephalostat.

above randomly grouped in a grid and labeled with letters A to H (Fig 2). Each photograph had a 10 cm x 5 cm size. The second and third sheets was composed of two pictures each and had the purpose of evaluating the monetary value of the apparatus. The second sheet (Fig 3) had a picture of the traditional fixed metallic appliance labeled “Picture A” and one of a fixed esthetic appliance labeled “Picture B”. The third sheet had a picture of a fixed esthetic appliance labeled “Picture A” and one of the clear tray aligner labeled “Picture B” (Fig 4). These sheets also had 29.7 cm x 21 cm, and each picture had 10 cm x 5 cm.

Eligibility to participate in the survey included any willing adult from 17 to 63 years old who had never undergone orthodontic treatment with brackets or aligners, was not a dentist or a dental student, was at the University campus in the four days of data collection and signed the informed consent form.

Two trained and blinded dental students collected the data. All surveys included a demographic and socioeconomic status information forms, instructions, the image-rating scales and the album. Socioeconomic status was measured with the “Brazil Economic Classification Criteria”,¹³ which classifies people into eight socioeconomic categories according to the educational level of the head of the household and the ownership and consumption of common goods and services (e.g., VCRs, DVDs, color TVs, housekeeper).

Each rater (n = 252) received the album containing the smiles’ photographs and a rating sheet with a 100 mm visual analog scale (VAS). The straight lines on the left side indicated “very unattractive” and, on the right side, “very attractive.” The subjects were presented the images that should be rated (Fig 2)

and instructed to use the VAS. They were also told not to compare the album smiles. After the attractiveness evaluation, questions were asked to determine the perceived value of cosmetic orthodontic appliances by using the WTP method.

The questions were directed to the evaluation of sheets 2 and 3. The rater received these instructions: “Assume the appliances in picture B are more expensive than those in Picture A. How much more would you be willing to pay for them to be placed on your teeth?” After that question, a second question asked how much more money the rater would be willing to pay to have Picture B appliances placed on “your child’s teeth”. The rater could check a box to represent the amount he or she would pay for Picture B appliances, ranging from US\$50 to US\$3500 (Table 1). Alternatively, if the rater would not pay additional money for the appliances in Picture B, the option: “None, I would prefer Picture A appliance” could be chosen. The procedure was repeated for sheets 2 (Fig 3) and 3 (Fig 4).

The scores were measured by a calibrated dentist using a digital caliper (MGF 505646, Mitutoyo, Tokyo, Japan) that was positioned on the left-most point of each line of the visual analog scale and opened to the mark made by the rater. Values in millimeters were registered as scores.

Statistical analysis

Sample size calculation showed that a total of 252 individuals would provide a 80% probability to the study of detecting a treatment difference at a one-sided 0.05 significance level, if the true difference between treatments is 0.30 times the standard deviation.³ The VAS scores were evaluated by intra-class correlation coefficient (ICC) with 95% upper and lower confidence bounds. For the WTP responses, the weighted kappa statistic was applied. Twenty subjects from the same University Campus, which were not included in the study group, were used to test the intrarater reliability. The interviews were repeated seven to ten days latter.

Descriptive statistics for perceived attractiveness VAS ratings were calculated. The Kolmogorov-Smirnov test showed lack of normality of distribution and heteroscedasticity for all groups except for sapphire esthetic brackets with metal wire.

Table 1 - Box representing how much more raters would pay for Picture B appliances, ranging from US\$50 to US\$3500, in sheets 2 and 3.

<input type="checkbox"/> US\$50	<input type="checkbox"/> US\$1000
<input type="checkbox"/> US\$100	<input type="checkbox"/> US\$1500
<input type="checkbox"/> US\$200	<input type="checkbox"/> US\$2500
<input type="checkbox"/> US\$250	<input type="checkbox"/> US\$3500
<input type="checkbox"/> US\$500	<input type="checkbox"/> None of the above. I would prefer picture A appliance

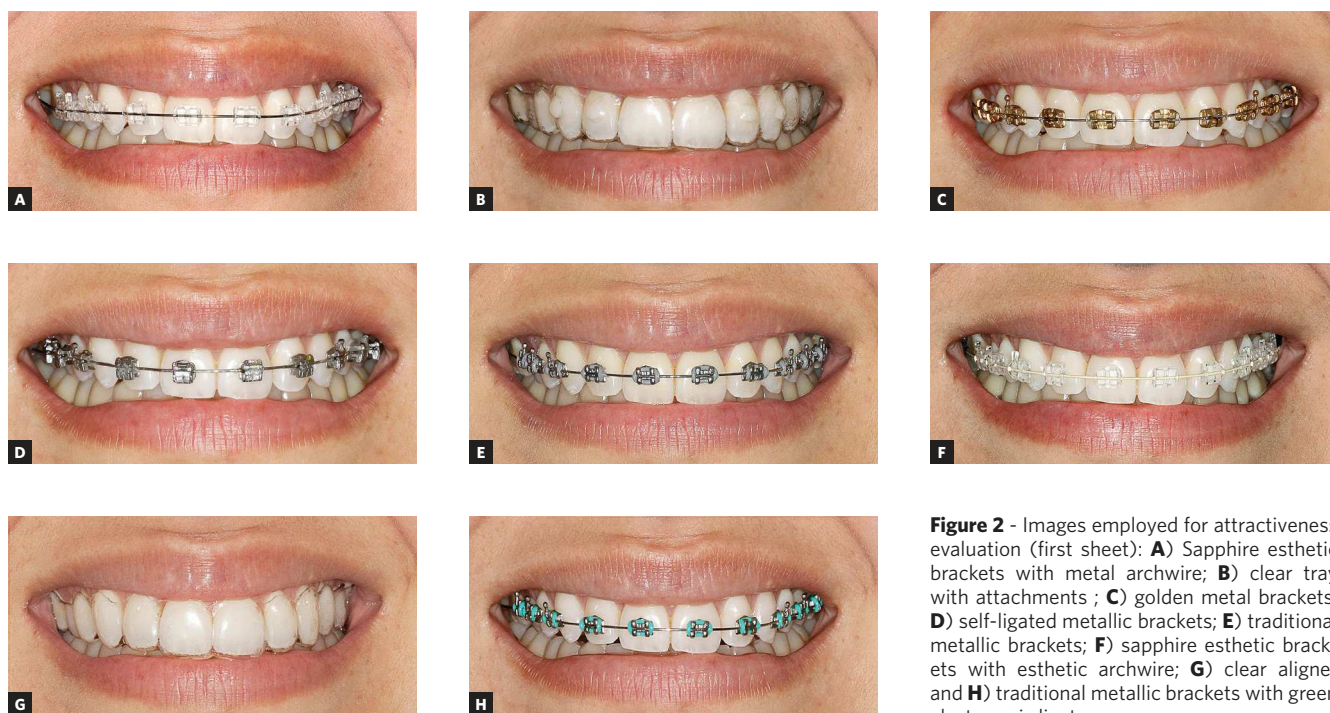


Figure 2 - Images employed for attractiveness evaluation (first sheet): **A**) Sapphire esthetic brackets with metal archwire; **B**) clear tray with attachments ; **C**) golden metal brackets; **D**) self-ligated metallic brackets; **E**) traditional metallic brackets; **F**) sapphire esthetic brackets with esthetic archwire; **G**) clear aligner and **H**) traditional metallic brackets with green elastomeric ligatures.

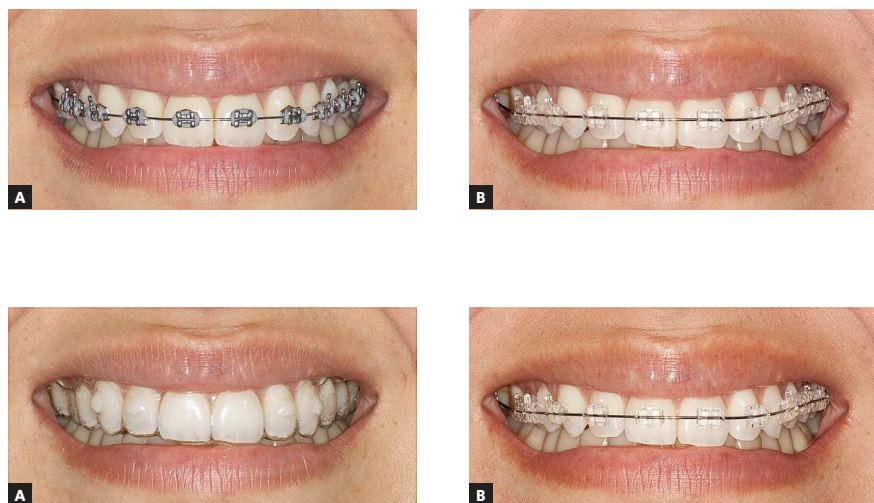


Figure 3 - Images captured for the first WTP evaluation (second sheet): **A**) Traditional metallic brackets; **B**) sapphire esthetic brackets with metal archwire.

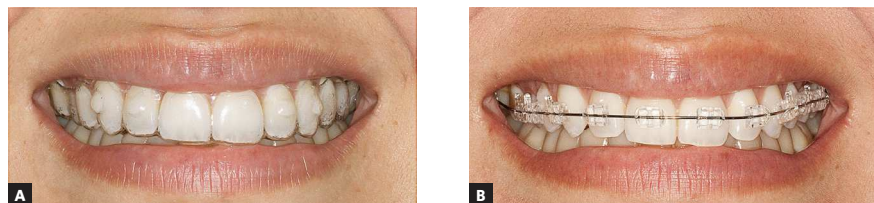


Figure 4 - Images captured for the second WTP evaluation (third sheet): **A**) Clear aligner with attachments; **B**) sapphire esthetic brackets with metal archwire.

Comparisons of groups' attractiveness were carried out using nonparametric statistics with the Friedman test (analysis of variance [ANOVA] on ranks for repeated measures) followed by Dann's multiple comparison post-hoc test (GraphPad Prism 5 software). The correlation between the economic value (WTP), socioeconomic status, age, gender and esthetic perception was calculated by using the Spearman correlation analysis and represented with the r value. Raters' ages were divided at the median (26 years) to assess whether it could influence the results.

RESULTS

Intraexaminer reliability was high for attractiveness assessment: Mean ICC = 0.83 (95% CI, 0.78-0.99) and for attributed value assessments: Kappa, 0.89 [95% CI, 0.81-0.98], indicating substantial consistency.¹⁴

The median for raters' age was 26 years old (IR= 22-40) and the socioeconomic status is described in Table 2. Descriptive statistics for the perceived attractiveness VAS ratings of sheet 1 are reported in Table 3 and Figure 5. Higher VAS scores (scored 0-100) indicate greater appliance attractiveness.

The clear aligner without attachments had the best evaluation scores, followed by the sapphire brackets with esthetic wire and then by the clear aligner with attachments. The golden metal brackets received the worse scores. The data show a general score hierarchy, with decreasing attractiveness as the amount of displayed metal increases, and worsening with the golden version.

Appliances perceived attractiveness for males and females was compared, showing significant difference between them, and it is described in Figure 6 and Table 4. Men showed a general tendency to assign lower scores than women. Similarly, there was a significant difference in the perception of groups of 17-26 years and 27-63 years of age, which is shown in Figure 7 and Table 5.

The correlation assessment between the attributed value (WTP) and the esthetic perception of the metal brackets with gray elastomeric ligatures (option A) in comparison with sapphire brackets with metal archwire (Option B) in sheet 2 revealed a weak¹⁴ but significant correlation regarding the raters themselves, and an even weaker and non significant result for their child. For the sapphire brackets with metal archwire (Option A) in comparison with the clear aligner with attachments (Option B) in sheet 3; there was also a weak¹⁴ but significant correlation for the raters themselves, with similar results for their

child (Table 6). Comparison between genders regarding WTP (Table 7) showed similar results to the total sample, with more significant results for sheet 3, with a slight tendency for women to pay less for appliances they considered more esthetic.

In sheet 2, the correlation between WTP and age showed a weak and non-significant correlation for the two age groups (Table 8). However, younger subjects (17-26 years) showed a tendency to pay more for the aligner in sheet 3. Correlation was significant and moderate.¹⁴ Socioeconomic status had a significant correlation, showing that as better is the socioeconomic status, as higher is the WTP for an esthetic appliance (Table 9). Correlation was similar and statistically significant for sheets 2 and 3.

DISCUSSION

Adult patients display pronounced different attitudes to the type of appliance they wear.¹⁵ They have indicated embarrassment and bashfulness,¹⁶ arising from the presence of a perceptible appliance, and negative peer reaction,¹⁵ especially from their partners, as discouraging aspects of treatment. The perception of young adults undergoing orthodontics by others is particularly important for major life events such as employment and finding a partner. Therefore, an orthodontic appliance with the most positive social assessment would favor patient acceptance.⁶

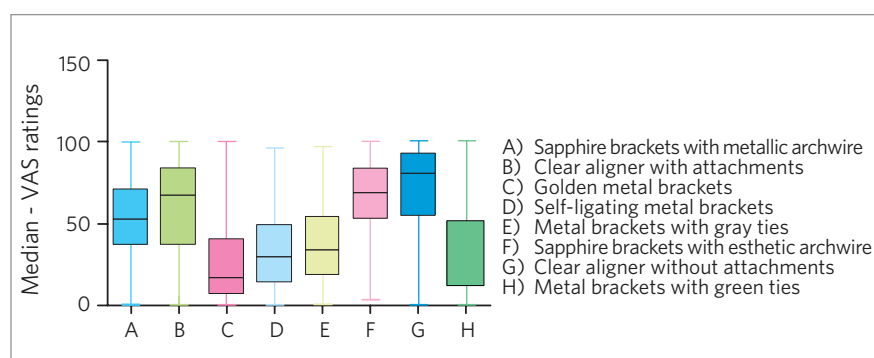
Table 2 - Sample description.

AGE (n = 252)	Mean	Standard Deviation	Min.	25% Percentile	median	75% Percentile	Max.
	31	11.2	17	22	26	40	63
GENDER (n = 252)	Frequency	Percentage					
Male	152	60.3					
Female	100	39.7					
SOCIOECONOMIC STATUS (n = 252)	Frequency	Percentage					
A1	6	2.4					
A2	61	24.2					
B1	62	24.6					
B2	68	26.9					
C1	42	16.6					
C2	10	3.9					
D	3	1.2					

Table 3 - Statistical comparison of the VAS ratings representing attractiveness evaluation with Friedman ANOVA for repeated measures ($p < 0.001$) and Dunn's post-hoc test.

n = 252			
VAS	Median	25% Percentile	75% Percentile
A) Sapphire brackets with metal archwire	54 ^a	38	70
B) Clear aligner with attachments	68 ^a	37.5	83
C) Golden metal brackets	17 ^b	7.5	39.5
D) Self-ligated metal brackets	30 ^b	15	48.5
E) Metal brackets with gray ties	34 ^b	20	53.5
F) Sapphire brackets with esthetic archwire	69 ^{a,c}	53	82.5
G) Clear aligner without attachments	81 ^c	55	92
H) Metal brackets with green ties	29 ^b	13	50

* Distinct superscripts indicate statistical significance.

**Figure 5** - Descriptive VAS ratings representing attractiveness evaluation for each appliance type.**Table 4** - Statistical comparison of the VAS ratings representing attractiveness evaluation with Friedman ANOVA for repeated measures ($p < 0.001$) and Dunn's post-hoc test by gender.

Males (n = 152)			
VAS	Median	25% Percentile	75% Percentile
A) Sapphire brackets with metal archwire	53 ^a	40	67
B) Clear aligner with attachments	66.5 ^{a,b}	38	83
C) Golden metal brackets	15.5 ^c	5	42.75
D) Self-ligated metal brackets	30 ^{c,d}	14	47.75
E) Metal brackets with gray ties	34 ^{d,e}	20.25	54
F) Sapphire brackets with esthetic archwire	68 ^{b,f}	53	84.5
G) Clear aligner without attachments	76 ^f	48.25	92
H) Metal brackets with green ties	29.5 ^{c,d,e}	13.25	50

Females (n = 100)			
VAS	Median	25% Percentile	75% Percentile
A) Sapphire brackets with metal archwire	53 ^{a,b}	36	74
B) Clear aligner with attachments	71 ^{a,c}	38	85
C) Golden metal brackets	20 ^c	11	38
D) Self-ligated metal brackets	31 ^d	18	50
E) Metal brackets with gray ties	32 ^d	19	52
F) Sapphire brackets with esthetic archwire	71 ^b	51	81
G) Clear aligner without attachments	83 ^c	63	93
H) Metal brackets with green ties	27 ^d	11	50

* Distinct superscripts indicate statistical significance.

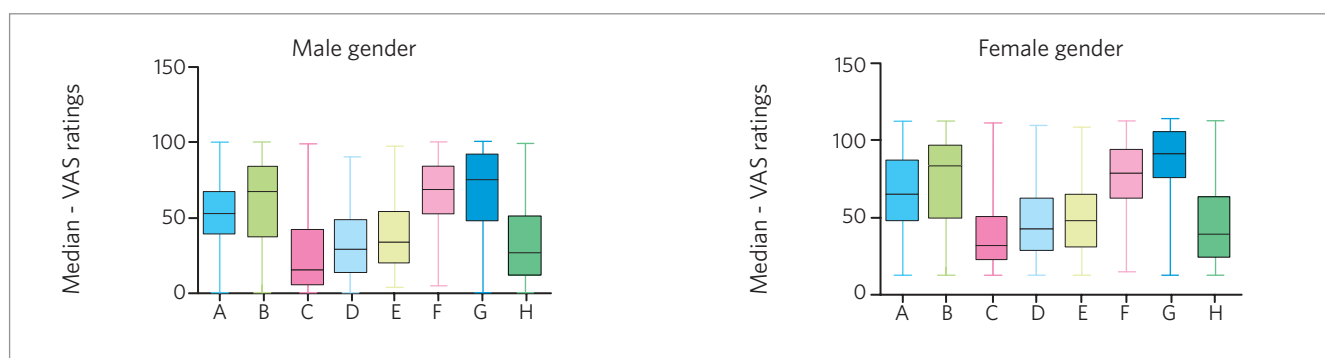


Figure 6 - Descriptive VAS ratings representing attractiveness evaluation for appliance type by gender.

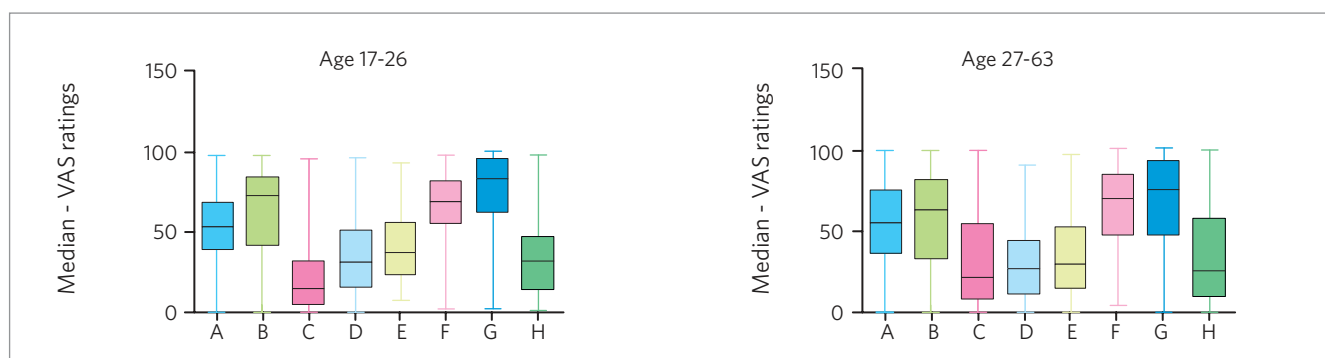


Figure 7 - Descriptive VAS ratings representing attractiveness evaluation for appliance type by age.

Table 5 - Statistical comparison of the VAS ratings representing attractiveness evaluation with Friedman ANOVA for repeated measures ($p < 0,001$) and Dunn's post-hoc test by age.

17 - 26 years (n = 128)			
VAS	Median	25% Percentile	75% Percentile
A) Sapphire brackets with metal archwire	52 ^a	39	67
B) Clear aligner with attachments	72 ^{a,b}	42	84
C) Golden metal brackets	15	5	31
D) Self-ligated metal brackets	32 ^c	16	51
E) Metal brackets with gray ties	36 ^c	23	55
F) Sapphire brackets with esthetic archwire	68 ^{b,d}	56	81
G) Clear aligner without attachments	83 ^d	63	95
H) Metal brackets with green ties	31 ^c	16	47
27 - 63 years (n = 124)			
VAS	Median	25% Percentile	75% Percentile
A) Sapphire brackets with metal archwire	54 ^a	36	75
B) Clear aligner with attachments	63 ^{a,b}	33.5	83.5
C) Golden metal brackets	22 ^c	9	53.5
D) Self-ligated metal brackets	27 ^c	11.5	43.5
E) Metal brackets with gray ties	29 ^c	15	52
F) Sapphire brackets with esthetic archwire	70 ^{a,d}	47	85
G) Clear aligner without attachments	75 ^{b,d}	48	91.5
H) Metal brackets with green ties	26 ^c	10	57

* Distinct superscripts indicate statistical significance.

Table 6 - Spearman rank correlation coefficients and p values between VAS score differences and attributed value (WTP).

Total sample (n = 152)	Attributed value (WTP)	
SHEET 2	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score E (Metal brackets with gray ties)	0.141* (p = 0.021)	0.090 (p = 0.143)
SHEET 3	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score B (Clear aligners with attachments)	-0.211** (p < 0.001)	-0.217** (p < 0.001)

*p < 0.05; **p < 0.01.

Table 7 - Spearman rank correlation coefficients and p values between VAS score differences and attributed value (WTP) by gender.

Males (n = 152)	Attributed value (WTP)	
SHEET 2	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score E (Metal brackets with gray ties)	0.141 (p = 0.067)	0.070 (p = 0.364)
SHEET 3	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score B (Clear aligner with attachments)	-0.340** (p < 0.001)	-0.289** (p < 0.001)
Females (n = 100)	Attributed value (WTP)	
SHEET 2	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal wire) - VAS score E (Metal brackets with gray ties)	0.143 (p = 0.162)	0.130 (p = 0.205)
SHEET 3	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal wire) - VAS score B (Clear aligner with attachments)	-0.224* (p = 0.027)	-0.213* (p = 0.036)

*p < 0.05; **p < 0.01.

Table 8 - Spearman rank correlation coefficients and p values between VAS score differences and attributed value (WTP) by age.

17 - 26 years (n = 128)	Attributed value (WTP)	
SHEET 2	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score E (Metal brackets with gray ties)	0.161 (p = 0.064)	0.089 (p = 0.309)
SHEET 3	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score B (Clear aligner with attachments)	-0.370** (p < 0.001)	-0.311** (p < 0.001)
27 - 63 years (n = 124)	Attributed value (WTP)	
SHEET 2	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score E (Metal brackets with gray ties)	0.093 (p = 0.293)	0.048 (p = 0.588)
SHEET 3	Personal attributed value	Children attributed value
Difference VAS score A (Sapphire brackets with metal archwire) - VAS score B (Clear aligner with attachments)	-0.218* (p = 0.013)	-0.234** (p < 0.001)

*p < 0.05; **p < 0.01.

Table 9 - Spearman rank correlation coefficients and p values between socioeconomic status and attributed value (WTP).

n = 252	Attributed value (WTP)	Attributed value (WTP)
SHEET 2	Personal attributed value	Children attributed value
Socioeconomic status	0.367** (p < 0.001)	0.164** (p < 0.001)
SHEET 3	Personal attributed value	Children attributed value
Socioeconomic status	0.375** (p < 0.001)	0.172** (p < 0.001)

*p < 0.05; **p < 0.01.

For this reason, this study's findings have direct clinical implications for the orthodontics practice. Orthodontists must choose between available appliances to provide options that are acceptable to patients and work in harmony with their biomechanical philosophy. This study showed that there were four general preference levels regarding types of appliances based on their appearance: 1) Clear aligners are preferred over sapphire appliances, except when attachments are present on anterior teeth; 2) In these cases, sapphire appliances with esthetic wires are preferred over the clear trays, but this was not statistically significant; 3) Sapphire brackets with both archwires are also preferred over stainless steel, but among those, traditional metal brackets with gray ties were preferred over self-ligated brackets and over metal brackets with green ties; 4) Golden metal brackets had the worse esthetic perception in this sample.

In the present study, all raters were University students or employees. This could have introduced bias into the results; especially with regard to their cultural and social background.²⁶ This was the main reason to apply a socioeconomic survey that allowed investigating whether it would influence the results. The survey showed that this sample was homogeneously distributed between the status A2, B1, B2 and C1 and socioeconomic status did not influence the esthetic perception of the appliances. However, it did influence the WTP for a more esthetic appliance.

Another issue worth discussing was the brackets positioning, which in spite of the 0.020-in archwire used as reference, showed minor variations.

However, it is most likely that these minor variations did not significantly impact our findings, especially because all appliances were installed on a model with well-aligned teeth. Although this situation might not represent the clinical appearance of these appliances during the early stages of treatment, well-aligned teeth were chosen to reduce variables that could distract from the evaluation of appliance esthetics and allow a more accurate comparison with the results of previous studies.

A similar study was recently carried out,⁶ interestingly, however, no significant differences were found between metallic, golden, and ceramic brackets for any of the assessed sample. Golden appliances are not widely used, leading the authors to believe that this may have influenced the results, since raters would not be able of identifying it properly. Nevertheless, the present study showed that this brackets had the worse esthetic perception in the studied population. According to Jeremiah et al,⁶ the clear aligner also had the higher attractiveness ratings. These findings indicate that a reduced appliance visibility appears to be the standard for social acceptance, corroborating our findings. In the present study, when the clear aligner was noticed, due to the presence of anterior attachments, it became less attractive than ceramic brackets. However no other study has previously evaluated the perception of anterior attachments, therefore, these results cannot be compared with other population.

Roswall et al³ and Ziuchkovski et al⁴ also evaluated appliances' esthetic perception and obtained similar results when compared with the present study.

The authors found that the overall trend in appliance attractiveness seems to relate to the amount of visible metal. Clear tray appliances with no visible metal received the highest ratings in attractiveness. Authors believe that this could explain why alternative orthodontic appliance systems such as clear tray aligners have grown in popularity.¹⁸ In fact, the present study and other three^{3,4,6} researches have shown similar results about clear tray aligners. Besides the positive esthetic perception and the increasing consumer and professional demand for such appliances, questions regarding this system's efficacy requires further research, since there is still much to learn about its biomechanics.^{19,20}

A possible reason for the marked differences in the results shown by Jeremiah et al⁶ and Ziuchkovski et al,⁴ Roswall et al,³ and the present study, regarding the perception of esthetic and metal brackets is that Jeremiah et al⁶ used standardized full-face photographs of a young adult female, whereas the other studies used smiles with no strong gender markers in the circum-oral region. The findings from Berto et al,²¹ who also used standardized lateral full-face close-ups photographs (modified by adding appliances) of a young female adult, differ from all studies discussed above. In their study, Brazilian laypeople perceived a smile with an esthetic appliance as significantly less attractive than a smile with a metal appliance or with no appliance. This could have been caused due to a different perception of the sapphire appliance, used in the present study, and the ceramic appliance, used in Berto et al²¹ and Jeremiah et al⁶ studies. On the other hand, this possibility is questionable once Roswall et al³ and Ziuchkovski et al⁴ also used ceramic brackets and found results that corroborates the present study.

It is important to know whether the attractiveness of a smile is influenced by the type of photographic framing used in the analysis. In addition, one must analyze methodologies that might influence the results achieved, such as, the order and fashion of presenting the photographs and the scale used to evaluate the perception.²² Some authors believe that facial structures, such as nose and chin, may act as confounding factors, as may also happen with gender markers apparent in the smile, and therefore influence the smile evaluation.²³ The model's gender is very influential when grading

smiles attractiveness, as was found by Thomas et al.²⁴ The use of a Lickert scale to rank esthetic perception and a structured questionnaire about characteristics strongly associated with the model's physical appearance may also have influenced the results of Jeremiah et al,⁶ since all other studies used a VAS scale.

Similarly, the sample's characteristics can also be related to differences in findings. In this study, raters' age and gender influenced attractiveness perception of the appliances. Younger patients (17-26 years old) evaluated sapphire appliances and clear aligners more positively, i.e. with highest scores, and golden and metallic brackets with green ties with worse scores than patients aged 27-63 years. Regarding gender, men showed a general tendency to assign lower scores than women for all evaluated appliances. Male subjects rated sapphire appliances and clear aligners without attachments statistically equal. On the other hand, for women there was no difference between clear aligners with and without attachments, conversely to what happened to men who perceived attachments negatively. Metallic brackets with gray and green ties and also self-ligated metal appliances were similar for women, but gold metal brackets had worse evaluation. Men also perceived metal brackets differently, considering only traditional metal appliances with gray ties more attractive than the others. Walton et al²⁵ also found significant differences in esthetic perception of appliances between genders and different age groups.

WTP method was used to evaluate the attributed value of various orthodontic appliances by means of a cost-benefit analysis. The WTP was assessed using the payment scale method, described in Table 1, rather than an open-ended format due to the study design and also because no difference was found between these two methods in previous studies.²⁶

The correlation between the attributed value (WTP) and the esthetic perception was weak, and showed that despite raters' preference for esthetic appliances, they would not be willing to pay more for clear tray and sapphire appliances according to the simulations made in sheets 2 and 3. Their socioeconomic status was significantly correlated with these results: The higher the socioeconomic status, the more raters were willing to pay for treatment with the appliances, as observed in the results for sheets 2 and 3.

This may be the reason for the different result found by Roswall et al,³ in which sample, raters with higher socioeconomic status responded with the highest WTP values for lingual appliances and a clear tray aligner. In another socioeconomic reality, different results may be found in Brazilian samples, therefore indicating that more studies are necessary to further conclusions regarding the subject. Therefore, it is important to note that this study's results cannot be indiscriminately applied to other cultural groups, with socioeconomic differences. These aspects must be analyzed and considered in this kind of analysis. When patients declared they would pay more for the esthetic appliances, adults were equally willing to pay more for appliances they deemed more desirable for their children too.

Gender had no significant influence on WTP, however, male subjects had a greater trend to pay more for treatment with a clear aligner. However, age had a significant influence in WTP for appliances compared in sheet 3, with younger patients being significantly more willing to pay more for a clear aligner. Similarly, attractiveness analysis was also influenced by age, as previously described. Walton et al²⁵ evaluated children and adolescents and found that they also showed high preference for clear tray aligners. However, following the aligners, child preferred metal appliances with colored ties above all other options. This was an opposite perception when compared to adults' rates and suggests that the comparison between different age groups influenced appliances' perceived esthetics and

could also have an effect on the attributed value. However, more studies comparing different age groups are required for definitive conclusions on the subject.

CONCLUSION

Orthodontic appliance attractiveness varied significantly by the following hierarchy of appliance types: Clear tray aligners > sapphire brackets > stainless steel traditional and self-ligating brackets > golden metal appliances. Metal appliances, commonly used in orthodontic practice, were considered unattractive, while clear aligners and sapphire appliances were considered better esthetic options. Nevertheless, patients are not willing to pay more for appliances they deem more esthetic. On the other hand, socioeconomic status and age was significantly correlated with WTP. Higher socioeconomic level and age between 17 and 26 years old were significantly correlated with the willingness to pay more for an esthetic appliance. Gender was not significantly correlated with WTP. These data show that results could vary depending on the studied sample. Therefore, a socioeconomic and age analysis is mandatory in this kind of study.

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