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Esthetic Perceptions of Maxillary Premolar Clinical Crown Height by Laypeople and Orthodontists

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Introduction

Smile esthetics are a driving motivator of patients seeking dental care and critical in evaluating outcomes of orthodontic treatment. The esthetic perception of a smile by patients is critical to a successful outcome and therefore critical for orthodontists to understand and appreciate patients' perceptions of a smile. A number of factors can affect the esthetic perception of a smile including tooth size and proportion, buccal corridor width, and gingival display [1]. A study of patient perceptions of smile esthetics found gingival display to be among the most significant factors [2]. Esthetic factors may be perceived differently by laypeople and orthodontists and highlight the importance in evaluating those perceptions when treatment planning [3].

Orthodontists utilize premolar extractions for a variety of purposes. Premolar extraction can resolve protrusion of either or both the maxillary and mandibular arches as well as alleviate moderate to severe crowding [4]. Antero-posterior relationships can be improved with premolar extraction as a method to camouflage a skeletal discrepancy. Premolar extractions may be used to remove dental compensations in order to prepare a patient for orthognathic surgery. An orthodontist might also choose to extract premolars to improve the long-term stability of occlusion [5].

A number of factors such as location and severity of crowding, dental compensations due to underlying skeletal discrepancies, anchorage concerns can affect the decision to extract first or second premolar [5]. Expected treatment time and existing restorative condition and prognosis of teeth may delineate an extraction strategy [6]. Anchorage concerns affect treatment mechanics and some authors suggest extracting second premolars when anchorage needs are

minimal. Clinical crown height and gingival margin contours can contribute to smile esthetics. Patient desire and esthetic considerations of the tooth proportion and gingival height play a role in determining treatment [7].

Several key differences exist between maxillary first and second premolars. Maxillary first premolars tend to have larger crown heights while second premolars are shorter. Gingival margin contours are esthetically important and maxillary first premolars more closely approximate the adjacent canine than second premolars [8].

This study proposes to examine the esthetic perception by laypeople and orthodontists of premolar extractions by focusing on the clinical crown heights of maxillary first and second premolars. Participants were surveyed to choose the more esthetic photograph among a series of altered photographs simulating first and second premolar extractions. The results were analyzed to determine the esthetic preferences for clinical crown height. It was hypothesized that laypeople would have no significant difference in perception of premolar clinical crown height while orthodontists would find a premolar with longer clinical crown height more esthetic than a premolar with shorter clinical crown height. This study aims to explore the preference for premolars of varying crown heights aid orthodontists in treatment planning premolar extraction patterns and adjunctive procedures such as gingivectomy or clinical crown lengthening.

Materials and Methods

This study was approved by the Institutional Review Board of the 59th Medical Wing, Lackland Air Force Base, Texas (FWH20210059E).

Eight volunteer models were photographed using an SLR camera and 85-mm macro lens (Nikon D7200, Tokyo, Japan) in a lateral smiling pose. Inclusion criteria included display of maxillary premolars on animation. Exclusion criteria included irregularly colored restorations visible on animation and significant distractors such obstructive facial hair. Photos were cropped to eliminate facial anatomy such as nose, chin, and cheeks to minimize distractions and emphasize focus on the dentition. (Fig 1)

This initial photo was digitally altered using Photoshop Elements software (Adobe Systems, San Jose, CA). One of the two existing premolars was digitally edited out of the photograph to display a single premolar and represent orthodontic treatment that included a single premolar extraction. The resulting photograph was used as a matrix photo for the subsequent variations of clinical crown height of the premolar. The clinical crown height of the premolar was digitally altered proportional to the mesial canine tooth of the individual model based on published normative values [8]. (Fig 1)

Photo ‘A’ displayed a premolar with clinical crown height 83% (“High”) of the mesial canine. Photograph ‘B’ displayed a premolar with the relatively shorter clinical crown height of 70% (“Medium”) of the mesial canine consistent with normative proportions of a second premolar.

Photograph 'C' displayed a premolar with the clinical crown height 1 standard deviation shorter than the established proportions for a second premolar at 61% (Low) of the mesial canine (Fig 2). Digital alterations of the photos were limited to the crown height of the premolar. This process was repeated for each of the eight models for a total of 24 images.

A survey was designed using SurveyMonkey software (Momentive Inc., San Mateo, CA). The first question asked the participant to select the more esthetic image of the various premolar crown heights (Fig 3). The second, third, and fourth questions asked the participant to select the more esthetic image of two of the individual model's photos comparing the "High vs Low", "High vs Medium" and "Medium vs Low" premolar clinical crown heights (Fig 4). The photographs were randomized within each model set to minimize bias. For each question in the survey, an option stating that the photographs were "Equally Esthetic" (Same) was available to participants. Participants of the survey evaluated 32 separate questions comparing model images. Additional questions were included collecting participant demographic information and consent for participation in the survey.

A link to the digital survey was posted in patient waiting areas of a postgraduate dental clinic and in various social media pages for orthodontists. Responses of complete surveys were collected and analyzed. Participants were divided into demographic categories including laypeople and orthodontists/orthodontic residents.

Statistical Analysis

Descriptive statistics including mean were collected for the demographic groups of laypeople and orthodontist/orthodontic residents. The percentage of each response of "Low", "Medium", "High", or "Same" was calculated into a mean for each type of response category as a continuous variable. Statistical analyses was performed using SPSS Statistics for Windows software Version 25 (IBM Corp., Armonk, NY). One way analysis of variance was used to analyze the continuous variables of premolar crown height within a participant category. Significance was set at $P < 0.0001$. Tukey post-hoc analysis was used to identify significance of responses. T-tests with Bonferroni correction were used to compare responses of laypeople and orthodontists/orthodontic residents.

Mean percentage responses of laypeople and orthodontic residents were compared to each other using T-tests with Bonferroni correction ($P<0.00385$).

Results

Table I shows the mean percentage responses of the 75 laypeople that completed the survey. Laypeople preferred the "High" premolar clinical crown height for seven of the eight models. The mean percentage response was 58.01% for the "High" premolar clinical crown height. Analysis of variance found that a significant difference occurred among laypeople responses ($P<0.001$). Tukey post-hoc analysis confirmed that laypeople selected the "High" premolar crown height significantly more than the responses of "Low", "Medium" or "Same".

Table II shows the mean percentage responses of the 56 orthodontists/orthodontic residents that completed the survey. Orthodontists/orthodontic resident preferred the "High" premolar clinical crown height for seven of the eight models. The mean percentage response was 85.28% for the "High" premolar clinical crown height. Analysis of variance found that a significant difference occurred among orthodontist/orthodontic resident responses ($P<0.001$). Tukey-post hoc analysis confirmed that orthodontists/orthodontic residents selected the "High" premolar crown height significantly more than the responses of "Low", "Medium" or "Same".

Table III shows the majority of respondents in both groups selected the higher clinical crown height as more esthetic in seven of the eight models. The "Medium" clinical crown height for Model #2 was selected as more esthetic by both groups compared to the "High" clinical crown in the remaining seven models.

Table III shows T-tests that revealed two significant differences between laypeople and orthodontists/orthodontic residents. When comparing the "Low-Medium-High-Same" questions, laypeople (6.66%) were significantly more likely to select the "Low" premolar clinical crown height than orthodontists/orthodontic residents (0.23%). Laypeople (17.99%) were significantly more likely than orthodontic/orthodontic residents (0.45%) to select that the premolar crown heights were equally esthetic.

Table IV shows T-tests that revealed two significant differences between laypeople and orthodontists/orthodontic residents. When comparing the "Low-Medium-Same" questions, orthodontists/orthodontic residents (92.43%) were significantly more likely than laypeople (64.84%) to select the "Medium" premolar clinical crown height as more esthetic over the "Low" crown height. Laypeople (24.84%) were significantly more likely than orthodontists/orthodontic residents (5.13%) to select that the premolar crown heights were equally esthetic.

Table V shows T-tests that revealed no significant differences between laypeople and orthodontists/orthodontic residents when comparing the "Low-High-Same" questions. Both groups selected the "High" crown as more esthetic in seven of eight models.

Table VI shows T-tests that revealed no significant differences between laypeople and orthodontists/orthodontic residents when comparing the "Medium-High-Same" questions. Laypeople selected the higher clinical crown as more esthetic in all eight models while orthodontists selected the higher clinical crown in seven of eight models.

Discussion

This study was designed to quantitatively evaluate esthetic perceptions of maxillary premolar clinical crown height by laypeople and orthodontists. The null hypotheses that both laypeople and orthodontists will not find a significant difference in esthetic perception of maxillary premolar clinical crown height were rejected. The experimental hypotheses that both laypeople and orthodontists would prefer the higher clinical crown height were accepted. The results of

this study indicate that both laypeople and orthodontists prefer higher maxillary premolar clinical crown heights. For both demographic groups, the higher premolar crown height was selected as more esthetic.

Comparable to other studies on smile esthetics, this study found that laypeople and orthodontists mostly agreed on smile esthetics [9]. Some studies have shown that differences occur between laypeople and orthodontists/orthodontic when evaluating smile esthetics [10]. Laypeople have been shown to reliably identify characteristics of a smile considered to be esthetic [11]. While overall this study found similar results, of the 13 T-tests evaluating participant responses, four significant differences were noted among the two demographic groups. Two differences occurred when comparing the "Low-Medium-High" photos. Laypeople were significantly more likely to select the Low or Same images as more esthetic than orthodontists (Table III). When comparing the "Low" and "Medium" crown images, laypeople were more likely to select that the crowns were equally esthetic and less likely to select the "Medium" crown height over the low crown height has more esthetic (Table IV). Cumulatively these differences suggest that while both groups chose the higher crown as more esthetic, laypeople are less discerning than orthodontists when evaluating maxillary premolar crown heights.

This study is believed to be the first to evaluate the preferences of maxillary premolar clinical crown height in a lateral smiling view by laypeople and orthodontists/orthodontic residents. Numerous studies exist analyzing smile esthetics and popular metric systems include the visual analogue scale, Likert scale, and dichotomous response formats [12]. Advantages and disadvantages exist for each system and this study utilized question formats requesting the participant choose one of either two or three images. An option was included for each question to select that the images were equally esthetic in an effort increase validity of responses by not forcing participants to choose that a photo as more esthetic if the participant did not actually appreciate a difference.

The alterations to the premolar images are based on published normative ratios of clinical crown height from periodontal literature [8]. Broader normative data could possibly alter these ratios or provide more realistic representations of premolar crown height. The digital alterations of the premolar teeth in the images are the best attempt of the authors and efforts were made to minimize changes to present the most natural shape, color and condition of teeth possible. Heavily edited photos can look artificial, distract the participant from evaluating the intended parameters, and result in inaccurate evaluation of photographic images [13].

In an effort to reach a broad range of participants the web-push online survey format was utilized which allowed participants to access the questions from a tablet, smart phone, or home computer. Web based surveys provide flexibility in reaching participants and are less expensive to conduct than paper only surveys [14]. A limitation of this method is that individual devices can vary widely in screen size and resolution. This could possibly affect a participant's ability to evaluate an image. This study could be repeated with a standardized photograph printed on paper and mailed to individual participants to study potential differences in survey methods.

Many viable and variable ways have been published to study smile esthetics. The survey-based approach in this study incorporated a lateral animation pose to focus on maxillary premolar crown architecture. While not all people will display premolar teeth based on buccal corridors, the authors felt the lateral pose used in this study was representative of a natural smile and suited for evaluation. Other orthodontic studies utilized a posed smile as a way of evaluating smile esthetics [9]. Since smiles that are considered esthetic have been shown to display of the dentition including the first molar, evaluation of premolar esthetics should be accounted for in treatment planning [15].

Esthetics have been a driving factor in orthodontics since the beginning of the specialty and are more important than ever to the profession [16]. Maxillary first premolars have higher clinical crown heights than second premolars [8]. Since both groups in this study preferred the higher crown height, if an orthodontic treatment plan includes premolar extractions the treating provider may consider extraction of second premolars to meet esthetic demands of the patient. Additionally, adjunctive procedures such as clinical crown lengthening or gingivectomy can enhance the esthetic outcome of treatment.

Conclusions

- Orthodontists should be aware of esthetic preferences of laypeople.
- Laypeople and orthodontists prefer higher maxillary premolar clinical crown heights.
- Orthodontists should carefully consider extraction patterns and adjunctive procedures to enhance gingival architecture and crown height when treatment planning as appropriate.

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References

1. Ghaffar F, Fida M. Effect of extraction of first four premolars on smile aesthetics. Eur J Orthod. 2011 Dec;33(6):679-83.
2. Chang CA, Fields HW Jr, Beck FM, Springer NC, Firestone AR, Rosenstiel S, Christensen JC. Smile esthetics from patients' perspectives for faces of varying attractiveness. Am J Orthod Dentofacial Orthop. 2011 Oct;140(4):e171-80.
3. Suzuki, L, Machado, A., and, Bittencourt, M. Perceptions of gingival display aesthetics among orthodontists, maxillofacial surgeons and laypersons. Rev. Odonto Ciênc. 2009;24(4):367-371
4. Bowman SJ, Johnston LE Jr. The esthetic impact of extraction and nonextraction treatments on Caucasian patients. Angle Orthod. 2000 Feb;70(1):3-10.
5. Proffit WR. 5th ed. St. Louis: Mosby – Year Book; 2012. Contemporary Orthodontics.

6. Janson G, Maria FR, Barros SE, Freitas MR, Henriques JF. Orthodontic treatment time in 2- and 4-premolar-extraction protocols. Am J Orthod Dentofacial Orthop. 2006 May;129(5):666-71.
7. Del Monte S, Afrashtehfar KI, Emami E, Abi Nader S, Tamimi F. Lay preferences for dentogingival esthetic parameters: A systematic review. J Prosthet Dent. 2017 Dec;118(6):717-724.
8. Volchansky A, Cleaton-Jones P. Clinical crown height (length)--a review of published measurements. J Clin Periodontol. 2001 Dec;28(12):1085-90.
9. Havens DC, McNamara JA Jr, Sigler LM, Baccetti T. The role of the posed smile in overall facial esthetics. Angle Orthod. 2010 Mar;80(2):322-8.
10. Kaur, S, Soni, S, Prashar, A, & Kaur, A. Perception and characterization of posed smile: A photographic study. Journal of Indian Orthodontic Society. 2021 55(3), 270-277.
11. Ker AJ, Chan R, Fields HW, Beck M, Rosenstiel S. Esthetics and smile characteristics from the layperson's perspective: a computer-based survey study. J Am Dent Assoc. 2008 Oct;139(10):1318-27.
12. Oliveira PL, Motta AF, Guerra CJ, Mucha JN. Comparison of two scales for evaluation of smile and dental attractiveness. Dental Press J Orthod. 2015 Mar-Apr;20(2):42-8.
13. Nightingale SJ, Wade KA, Watson DG. Can people identify original and manipulated photos of real-world scenes? Cogn Res Princ Implic. 2017;2(1):30.
14. McMaster HS, LeardMann CA, Speigle S, Dillman DA; Millennium Cohort Family Study Team. An experimental comparison of web-push vs. paper-only survey procedures for conducting an in-depth health survey of military spouses. BMC Med Res Methodol. 2017 Apr 26;17(1):73.
15. Dong JK, Jin TH, Cho HW, Oh SC. The esthetics of the smile: a review of some recent studies. Int J Prosthodont. 1999 Jan-Feb;12(1):9-19.
16. Turley PK. Evolution of esthetic considerations in orthodontics. Am J Orthod Dentofacial Orthop. 2015 Sep;148(3):374-9.

Tables

Table I

Layperson Percentage Responses (n=75)						
Model	Respondent	Low61	Med70	High83	Same	Total %
1	Lay	5.3	5.3	45.3	44	100
2	Lay	10.7	45.3	22.7	21.3	100
3	Lay	6.7	21.3	56	16	100
4	Lay	5.3	2.7	82.7	9.3	100
5	Lay	5.3	6.7	74.7	13.3	100
6	Lay	6.7	12	62.7	18.7	100
7	Lay	5.3	29.3	52	13.3	100
8	Lay	8	16	68	8	100
	Lay Mean	6.66	17.33	58.01	17.99	100
	Lay stdev	1.91	14.36	18.74	11.41	

Table II

Orthodontist/Orthodontic Resident Percentage Responses (n=56)						
Model	Respondent	Low61	Med70	High83	Same	Total %
1	Ortho	0	1.8	96.4	1.8	100

2	Ortho	1.8	55.4	42.9	0	100
3	Ortho	0	12.5	87.5	0	100
4	Ortho	0	0	100	0	100
5	Ortho	0	0	100	0	100
6	Ortho	0	19.6	78.6	1.8	100
7	Ortho	0	12.5	87.5	0	100
8	Ortho	0	10.7	89.3	0	100
	Ortho Mean	0.23	14.06	85.28	0.45	100
	Ortho stdev	0.64	18.13	18.61	0.83	

Table III

Comparison of Mean Percentage Responses: Low, Medium, High, Same					
Model	Respondent	Low61	Med70	High83	Same
1	Lay	5.3	5.3	45.3	44
2	Lay	10.7	45.3	22.7	21.3
3	Lay	6.7	21.3	56	16
4	Lay	5.3	2.7	82.7	9.3
5	Lay	5.3	6.7	74.7	13.3
6	Lay	6.7	12	62.7	18.7
7	Lay	5.3	29.3	52	13.3
8	Lay	8	16	68	8
1	Ortho	0	1.8	96.4	1.8
2	Ortho	1.8	55.4	42.9	0
3	Ortho	0	12.5	87.5	0
4	Ortho	0	0	100	0
5	Ortho	0	0	100	0
6	Ortho	0	19.6	78.6	1.8
7	Ortho	0	12.5	87.5	0
8	Ortho	0	10.7	89.3	0
	T-test	**0.0000**	0.6963	0.0112	**0.0033**
Bonferroni Correction					

P<0.00385	sig	NS	NS	sig

Table IV

Comparison of Mean Percentage Responses: Low, Medium, Same				
Model	Respondent	Low_Med61	Low_Med70	Low_MedSame
1	Lay	17.3	28	54.7
2	Lay	17.3	52	30.7
3	Lay	4	80	16
4	Lay	10.7	78.7	10.7
5	Lay	6.7	70.7	22.7
6	Lay	9.3	69.3	21.3
7	Lay	5.3	73.3	21.3
8	Lay	12	66.7	21.3
1	Ortho	0	80.4	19.6
2	Ortho	3.6	96.4	0
3	Ortho	0	100	0
4	Ortho	0	100	0
5	Ortho	0	98.2	1.8
6	Ortho	16.1	80.4	3.6
7	Ortho	0	92.9	7.1
8	Ortho	0	91.1	8.9
	T-test	0.0110	**0.0022**	**0.0037**
Bonferroni Correction				

P<0.00385	NS	sig	sig

Table V

Comparison of Mean Percentage Responses: Low, High, Same				
Model	Respondent	Low_Hi61	Low_Hi80	Low, Hi, Same
1	Lay	10.7	66.7	22.7
2	Lay	26.7	52	21.3
3	Lay	6.7	70.7	22.7
4	Lay	13.3	40	46.7
5	Lay	1	85.3	13.3
6	Lay	13.3	70.7	16
7	Lay	12	73.3	14.7
8	Lay	9.3	76	14.7
1	Ortho	0	100	0
2	Ortho	8.9	89.3	1.8
3	Ortho	0	96.4	3.6
4	Ortho	0	50	50
5	Ortho	0	100	0
6	Ortho	1.8	98.2	0
7	Ortho	0	100	0
8	Ortho	0	100	0
	T-test	0.0049	0.0075	0.0685
Bonferroni Correction				

P<0.00385	NS	NS	NS

Table VI

Comparison of Mean Percentage Responses: Medium, High, Same				
Model	Respondent	Med_Hi70	Med_Hi83	Med_HiSame
1	Lay	12	64	24
2	Lay	36	37.3	26.7
3	Lay	10.7	68	21.3
4	Lay	6.7	80	13.3
5	Lay	1.3	72	26.7
6	Lay	13.3	52	34.7
7	Lay	26.7	64	9.3
8	Lay	20	64	16
1	Ortho	0	100	0
2	Ortho	55.4	41.1	3.6
3	Ortho	5.4	91.1	3.6
4	Ortho	0	100	56
5	Ortho	0	78.6	21.4
6	Ortho	0	89.3	10.7
7	Ortho	7.1	92.9	0
8	Ortho	8.9	85.7	5.4
	T-test	0.4381	0.0181	0.2507
Bonferroni Correction				

P<0.00385	NS	NS	NS

Figures

Fig 1. Summary workflow of alterations of model images. **A**. Lateral animated smile. **B**. Digitally altered photograph to display a single maxillary premolar. **C**. Magnified photo of premolar area with points marked along long axis of tooth to define various clinical crown heights. **D**. Various lines representing ratios of maxillary canine to a first or second premolar. Red, yellow, and green lines correspond respectively to ratios of clinical crown heights of first, second, and 'low' second premolars to canines based on published norms.

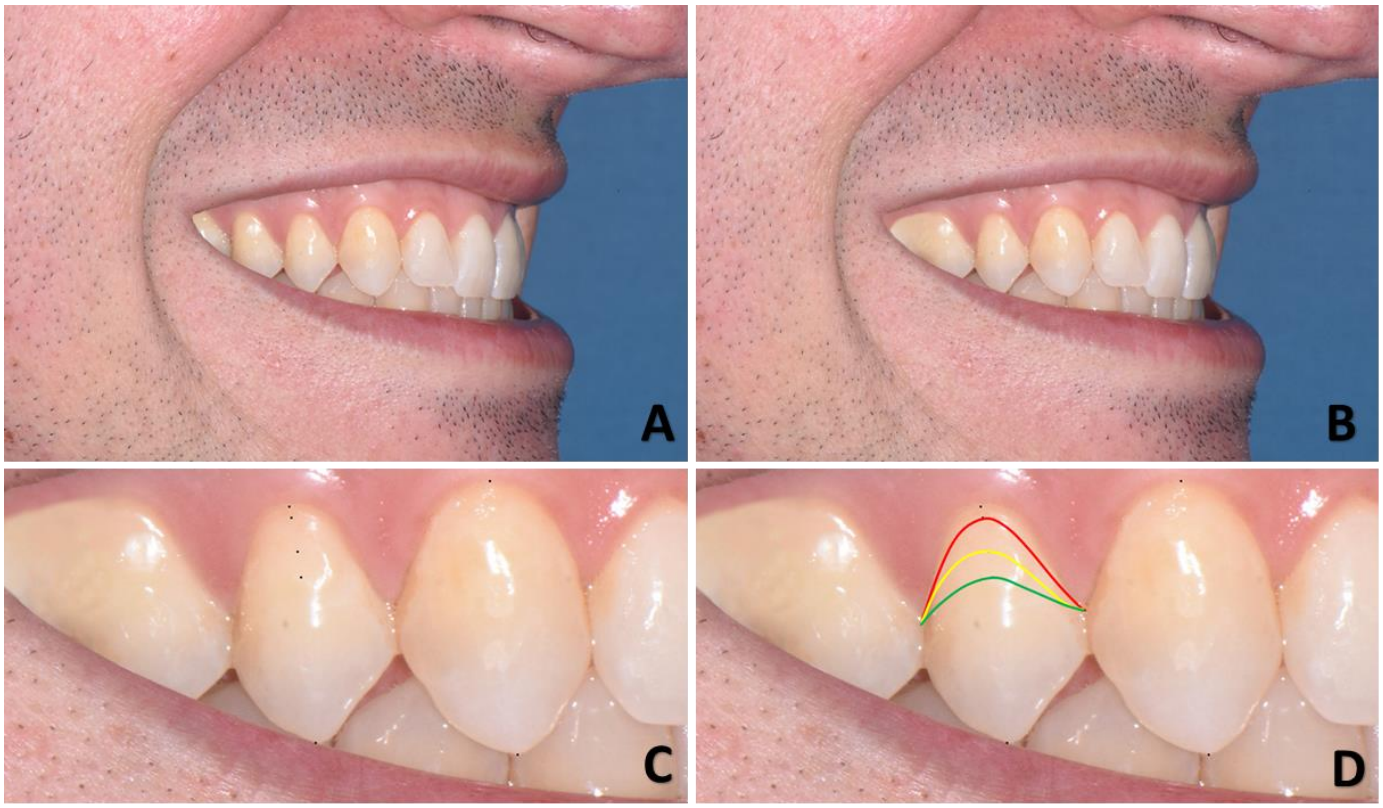

Fig 2. Final model images of altered maxillary premolar clinical crown heights based on ratios of published normative data. **A.** “High” image representing a maxillary first premolar displaying 83% of clinical crown height of maxillary canine. **B.** “Medium” image representing a maxillary second premolar displaying 70% of clinical crown height maxillary canine. **C.** “Low” image representing a maxillary premolar with a clinical crown height 1 standard deviation lower than a second premolar.

Fig 3. Example survey question displaying “Low”, “Medium”, “High”, or answer option of “These photos are equally esthetic”.

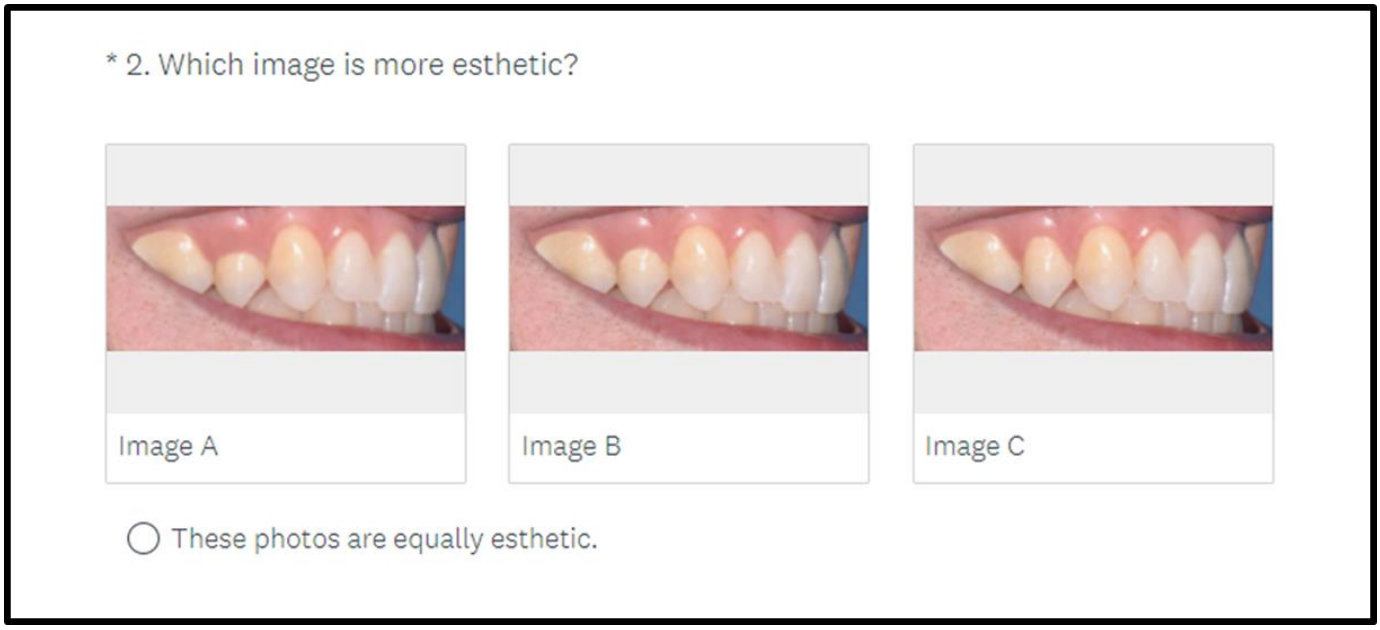

Fig 4. Example survey questions comparing “Low” to “Medium”, “Medium” to “High”, and “Low” to “High”. All survey questions included an option to state that the images were equally esthetic.

* 3. Which image is more esthetic?

Image A

Image B

◯ These photos are equally esthetic.

* 5. Which image is more esthetic?

Image B

Image C

◯ These photos are equally esthetic.

* 4. Which image is more esthetic?

Image A

Image C

◯ These photos are equally esthetic.