UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
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AVALIAÇÃO IN VITRO DA RESISTÊNCIA DE UNIÃO AO CISALHAMENTO DE BRÁQUETES CERÂMICOS MONOCRISTALINOS

Porto Alegre
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AVALIAÇÃO IN VITRO DA RESISTÊNCIA DE UNIÃO AO CISALHAMENTO DE BRÁQUETES CERÂMICOS MONOCRISTALINOS

Trabalho de Conclusão de Curso apresentado ao Curso de Graduação em Odontologia da Faculdade de Odontologia da Universidade Federal do Rio Grande do Sul, como requisito parcial para obtenção do título de Cirurgiã-Dentista.

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RESUMO

SCHWARZBACH, Marília. **Avaliação *in vitro* da resistência de união ao cisalhamento de bráquetes cerâmicos monocristalinos**. 2015. 23 f. Trabalho de Conclusão de Curso (Graduação em Odontologia) – Faculdade de Odontologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2015.

Após a mudança do tipo de adesão dos bráquetes cerâmicos monocristalinos de química para mecânica poucos estudos foram feitos para avaliar se os problemas que antes eram encontrados durante a descolagem desses bráquetes foram resolvidos. Esta pesquisa tem como objetivo avaliar *in vitro* a resistência de união ao cisalhamento de bráquetes cerâmicos monocristalinos de quatro diferentes marcas. Para isso foi utilizada a superfície vestibular do esmalte de 60 incisivos inferiores bovinos, de precedência certificada onde os baquetes cerâmicos monocristalinos foram colados: Eurodonto®, American Orthodontics®, Orthometric® e Ortho Technology®. Após 24 horas da sua colagem, os bráquetes foram descolados por meio do processo de cisalhamento com a Máquina Universal de Ensaios Mecânicos (EMIC DL2000). A superfície do esmalte dentário foi avaliada através do Índice de Adesivo Remanescente (IAR) a fim de que se determinar o tipo da falha de descolagem. Os resultados obtidos foram analisados por meio de estatísitica interferêncial utilizando-se o programa SigmaPlot 11.0 (California – USA). O valor mínimo de resistência de união encontrado foi 7,71 MPa no grupo A (Orthometric) e o máximo foi de 12,82 MPa no grupo W (Ortho Technology). A maioria dos bráquetes obteve um índice 3 no IAR, o que significa que todo o adesivo permaneceu aderido à surperfície dentária após a descolagem dos bráquetes. Todos os bráquetes testados obtiveram uma resistência de união ao cisalhamento considerada adequada. Não foi encontrado dano ao esmalte nem fratura dos bráquetes.

Palavras-chave: Bráquetes cerâmicos monocristalinos. Resistência de união ao cisalhamento. Índice de adesivo remanescente. *In vitro.*

ABSTRACT

SCHWARZBACH, Marília. ***In vitro* evaluation of monocrystalline ceramic brackets shear bond strength**. 2015. 23 p. Final Paper (Graduation in Dentistry) – Faculdade de Odontologia, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2015.

After the changes in the adhesion of monocrystalline ceramic brackets, from chemical retention to mechanical few studies were made to evaluate if the problems found during the debond were solved. Since there are little studies to evaluate if these problems were solved, the objective of this research is to evaluate *in vitro* the shear bond strength of four different brands of monocrystalline ceramic brackets. For that, the vestibular surface of 60 bovine mandibular incisors, with certificated precedence, were bonded with four brands of ceramic monocrystalline brackets: Eurodonto®, American Orthodontics®, Orthometric® and Ortho Technology®. After 24 hours the brackets were debonded using the shear test in a Universal Mechanical Testing Machine (EMIC DL2000). The amount of residual adhesive that remained following debond was evaluated with the Adhesive Remnant Index (ARI) to determine the bond failure interface. The obtained results were analyzed using the software SigmaPlot 11.0 (California – USA) to perform descriptive statistical analysis. The minimum bond strength founded was 7.71 MPa in group A (Orthometric) and the maximum was 12.82 MPa in group W (Ortho Technology). Most brackets presented an index 3 in the ARI, which means that all adhesive remained in the tooth surface after debonding. All brackets obtained an adequate bond strength during the shear process of debonding. No bracket fracture or enamel damage was reported.

Keywords: Monocrystalline ceramic brackets. Shear bond strength. Adhesive remnant index. *In vitro*.

SUMÁRIO

1 INTRODUÇÃO

Na atualidade há uma busca cada vez maior pela estética e isso se estende a todas as variáveis da vida humana. Com base nessa premissa, a ortodontia teve que evoluir para acompanhar os padrões de estética da sociedade. A estética deixou de ser apenas um resultado esperado ao final do tratamento ortodôntico e passou a ser requisitada em todas as etapas dele, especialmente no tratamento de um paciente adulto, que espera algo mais discreto do que os populares bráquetes metálicos (BISHARA; FEHR, 1997; OLIVEIRA; FURQUIM; RAMOS, 2012).

O desenvolvimento, instituído por Buonocore em 1955, possibilitou a substituição das bandas ortodônticas por bráquetes adesivos. A limitação estética dos bráquetes metálicos também foram contornadas pelo uso de aparelhos ortodônticos linguais, de aparelhos alinhadores transparentes, de bráquetes plásticos ou bráquetes cerâmicos monocristalinos ou policristalinos (ELIADES, 2007; SOUZA, 2012; THEODORAKOPOULOU et al., 2004).

Além da requisição de estética, os fabricantes buscaram por materiais com características físicas e funcionais mais adequadas ao bom tratamento ortodôntico. Sabe-se que os bráquetes cerâmicos apresentam boa estabilidade de cor quando comparados aos plásticos e maior resistência à oxidação quando comparados aos metálicos. No entanto, apresentam maior fragilidade, maior atrito com os fios ortodônticos (ARICI, N.; AKDENIZ; ARICI, S., 2015; BAGGIO; TELLES; DOMICIANO, 2007), maior dureza e menor resistência à tensão de tração e cisalhamento quando comparados aos metálicos. Por apresentarem uma dureza maior que a do esmalte dentário, podem causar lesões de abrasão nos dentes antagonistas quando estes ocluem contra os bráquetes. Devido a estes problemas, deve-se estudar a sua utilização caso a caso (BISHARA et al., 1999; MALTAGLIATI et al., 2006).

O que diferencia um bráquete monocristalino do policristalino é o seu processo de fabricação. Os monocristalinos são confeccionados a partir de alumina monocristalina, cujo processo de sinterização das partículas ocorre em temperaturas superiores a 2100ºC, o que cria um cristal de óxido de alumínio. Os policristalinos são confeccionados a partir de vários cristais de óxido de alumínio, alumina policristalina, que são aglutinados e fundidos a uma temperatura de 1800ºC. Assim, o método de confecção dos bráquetes monocristalinos tende a incorporar menos impurezas e a eliminar todos os grãos de óxido de alumínio, ao contrário do que acontece com os policristalinos (SOBREIRA; LORIATO; OLIVEIRA, 2007). Devido a essas diferenças na fabricação eles apresentam características físicas distintas. Os monocristalinos têm maior transparência, maior resistência à tensão de tração e cisalhamento e à fratura, menor atrito e menor deformação quando comparado aos policristalinos. Isto ocorre porque os vestígios de grãos de óxido de alumínio nos policristalinos tornam a sua estrutura mais opaca e suscetível à fraturas (FLORES et al., 1989; KARAMOUZOS; ATHANASIOU; PAPADOPOULOS, 1997; PINHEIRO et al., 2009).

Como o óxido de alumínio é um material quimicamente inerte, os primeiros bráquetes cerâmicos necessitavam do uso de adesão química no processo de colagem, pois eles não faziam adesão às resinas compostas utilizadas na década de 1980. A colagem era feita com a utilização de silano, que possibilitava a união entre a cerâmica e a resina composta. No entanto, isso gerava uma força de adesão muito grande, especialmente entre a resina composta e o bráquete, o que dificultava a sua descolagem (ARICI; MINORS, 2000; BISHARA et al., 1990).

Bishara (2000) avaliou dados obtidos de inúmeras pesquisas e chegou à conclusão de que uma resistência de união ao cisalhamento mínima entre 5,9 e 7,8 MPa era necessária para uma adesão eficaz do bráquete ao esmalte dentário, diminuindo a ocorrência de descolagens acidentais durante o tratamento ortodôntico. Além disso, a maioria dos adesivos existentes naquela época reportavam que uma resistência de união ao cisalhamento de 5,9 até 11,3 MPa era suficiente para uma descolagem posterior. Mas, em relação ao tecido dentário, foi referido que um valor de 13,5 MPa já era suficiente para serem notados danos ao esmalte dentário.

Como a aplicação de silano tornava a ligação entre a resina composta e a cerâmica muito forte, havia a necessidade da aplicação de mais força para a descolagem desses bráquetes. Este fato, junto com a alta rigidez da cerâmica implicava comumente na fratura do bráquete, ou seja, as falhas nas descolagens geralmente se davam na interface resina composta/dente, o que podia danificar o esmalte dentário (ARAÚJO; GRANDE; YOSHIMURA, 2012, 2013). Para superar essa limitação, os fabricantes desenvolveram novas técnicas de descolagem, como aquela com ultrassom e a eletrotérmica. Entretanto, por mais que essas técnicas parecessem uma boa alternativa, elas eram insatisfatórias, se comparadas da descolagem com o alicate de descolamento (BISHARA et al., 1994).

A solução dos fabricantes foi fazer retenções mecânicas na base dos bráquetes, para eliminar a adesão química, além disso houve um aprimoramento dos alicates de descolamento utilizados neste tipo de bráquete (BISHARA et al., 2008).

A partir de então poucos estudos foram realizados para avaliar a resistência de união ao cisalhamento e a descolagem de bráquetes cerâmicos monocristalinos, e ainda há dúvida e, consequentemente, receio no uso deles. Este estudo objetiva, assim, reduzir tais incertezas, mediante ensaios “in vitro” e que avaliem a resistência de união de quatro diferentes marcas comerciais de bráquetes cerâmicos monocristalinos disponíveis para venda no mercado brasileiro, bem como o tipo de fratura e a interface de falha de descolagem entre esmalte dentário/adesivo.

2 OBJETIVOS

Essa pesquisa teve como objetivo avaliar e comparar a resistência de união de bráquetes cerâmicos monocristalinos, analisando também a interface de descolagem adesivo/esmalte dentário de quatro diferentes marcas comerciais de bráquetes por meio do teste de cisalhamento e Índice de Adesivo Remanescente (IAR).

3 ARTIGO CIENTÍFICO

In vitro evaluation of monocrystalline ceramic bracket performance

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ABSTRACT

Objective: This *in vitro* study aims to evaluate the bond strength of four different brands of monocrystalline ceramic brackets as well as to evaluate the bond failure interface.

Materials and methods: 60 bovine mandibular incisors were bonded with ceramic monocrystalline brackets of four different brands: Eurodonto®, American Orthodontics®, Orthometric® and Ortho Technology®. After 24 hours the brackets were debonded using the shear test in a Universal Mechanical Testing Machine (EMIC DL2000). The Adhesive Remnant Index (ARI) was used to evaluate the bond failure interface. One-way analysis of variance (ANOVA) and the Tukey Test were used to assess the results of shear bond strength with a significance level of 0.001%. As for ARI, the data was submitted to the Kruskal-Wallis test also considering a significance level of 0.001%.

Results: The minimum bond strength found was 7.71 MPa in group A (Orthometric) and the maximum was 12.82 MPa in group W (Ortho Technology). Most of the brackets presented a index of 3 in the ARI, which means that all adhesive remained in the tooth surface after debonding.

Conclusion: All brackets obtained an adequate bond strength for clinical use and no bracket fracture or enamel damage was reported.

Keywords: *In vitro*; Shear bond strength; Monocrystalline ceramic brackets; Adhesive remnant index.

INTRODUCTION

Nowadays, the search for aesthetics is increasing and it is expanding for every area of our lives. Based on this, aesthetics started being required during all the orthodontic treatment stages, especially when it comes to an adult patient treatment [1, 2]. One aesthetic alternative to metallic brackets are ceramic brackets, which can be polycrystalline or monocrystalline [3, 4].

Both poly and monocrystalline ceramic brackets are made of alumina. The monocrystalline are made in a process that tend to correct the defects and incorporate fewer impurities[5]. As a result, they are more translucide and have a higher tensile strength than the polycrystalline [6, 7].

Aluminum oxide is chemically inert and cannot adhere to any polymeric bonding agent. So, to enable the bond to the enamel surface, the first ceramic brackets needed the use of chemical retention for its bonding process. The addiction of silane improved bond strength but also created a very high bond strength [8, 9, 10].

With chemical retention, the bond strength was so high that made debonding very difficult and a higher force was needed to remove the brackets. That, with the ceramic properties of high tensile strength, brittleness and stiffness, frequently resulted in the fracture of the bracket and enamel damage during that process[11]. Therefore, the solution found by the manufacturers was to develop mechanical retentions that were added to the bracket bases to discard the use of chemical retention [12, 13].

Since that, few studies were made to evaluate the bond strength of the monocrystalline ceramic brackets. Consequently, there are still some doubts about the performance of these type of brackets. Because of that, this study aims to evaluate and compare the shear bond strength and failure sites of four brands of monocrystalline ceramic brackets.

MATERIALS AND METHODS

The sample size was calculated for shear bond strength test using SigmaPlot 11.0 (California –USA) software for statistical analysis with a significance level of 5% and power of 80%. This project was approved by the Research Committee of the Federal University of Rio Grande do Sul (UFRGS) under the number of 28213.

Monocrystalline .022 slot Roth prescription, for upper central incisors ceramic brackets of four different brands: Eurodonto, with a brand-name Zetta®, American

Orthodontics, with a brand-name Radiance Plus®, Orthometric, with a brand-name Iceram-S® and Ortho Tecnology with a brand-name Pure® were used.

A total of 60 incisors were selected, cleaned with a scalpel and stored in distilled water at 4ºC. After all the teeth were sectioned, leaving about 1/3 of its root. Then, they were placed with its vestibular face perpendicular to a glass slab with the aid of a positioner and fixed in a PVC matrix (20mm diameter and 15mm high) using a self-curing acrylic resin (Policron/Dencril ®).

Once fixed, all samples were randomly divided into 4 groups, with 15 incisors in each one. The vestibular surface of each incisor was cleaned with a mix of water and fluoride-free pumice using a rubber polishing cup and rinsed with water to remove any pumice debris and dried with oil-free compressed air. Enamel surfaces were etched with 37% phosphoric acid for 30 seconds and then rinsed with tap water for 10 seconds and dried with compressed air for 3 seconds. After that step, all etched surfaces were sealed with one coat of resin primer Transbond XT (3M Unitek®) and cured with a light-cured unit for 10 seconds.

Subsequently, composite resin Transbond XT (3M Unitek®) was applied on the base of each bracket and the bracket was bonded on the vestibular surface of all teeth. A bonding force was standardized using a Gilmore needle of 1 pound in the center of the bracket, the excess was removed from the periphery of each bracket and light cured for 10 seconds, as described in the manufacturer's specifications. Only one bracket was bonded on each vestibular surface of each incisor.

After 24 hours, all brackets were debonded and the shear bond strength value was recorded using Universal Mechanical Testing Machine (EMIC DL2000) with standard speed of 0.5 mm/min. The results were obtained and expressed in MPa (megapascals) and analyzed with SigmaPlot 11.0 software (California -USA).

The amount of residual adhesive remaining following debonding was measured using the Adhesive Remnant Index (ARI). The ARI, as proposed by Artün and Bergland (1984)[14], is used to classify the enamel surface after debonding according to the following scores: score 0, no composite resin left on the tooth; score 1, less than half of the composite resin left on the tooth; score 2, more than half of the composite resin left on the tooth; score 3: all composite resin left on the tooth, with distinct impression of the bracket base. This index was used with the aid of an optical microscope to assess the composite remaining on the incisor after debonding and to compare the ARI scores among the groups.

RESULTS

The statistical analysis were performed by a SigmaPlot 11.0 software (California –USA). The data were analyzed for normal distribution by the Kolmogorov-Smirnov test, then submitted to the one way analysis of variance (ANOVA) and to Tukey's multiple comparison test (table 1). The data from ARI were submitted to the Kruskal-Wallis test (table 2). The significance level was 95%.

Shear bond strength test results for each group and brand are presented in table 1.

Table 1. Mean shear bond strength in megapascal (MPa) for each group.

Groups	Manufacturer	N	Mean shear bond strength (MPa)	Standart Deviation
W	Ortho Tecnology	15	12.82 ^{A}	2.18
J	American Orthodontics	15	9.35 $^{B\,C}$	1.56
K	Eurodonto	15	11.22 $^{A\,B}$	2.11
A	Orthometric	15	7.71 ^{C}	3.32

p = < 0.001. ^{A} p = 0.267; ^{B} p = 0.150; ^{C} p = 0.243.

The differences in the mean values among the treatment groups are greater than would be expected by chance, in other words, there is a statistically significant difference (p = <0.001). Group J was statistically different from W (p = 0.001), group A was statistically different from W (p = < 0.001) and K (p = 0.001). There was no statistical difference between groups K and W (p = 0.267), J and K (p = 0.150) and J and A (p = 0.243).

The lowest shear bond strength was 7.71 MPa obtained in group A. Meanwhile, group W had the highest shear bond strength with 12.82 MPa, but wasn't statistically different from group K which obtained a bond strength of 11.22 MPa.

The Index of Remnant Adhesive results are presented in table 2.

Table 2. Comparisons of the Adhesive Remnant Index (ARI) ratings in each brand group.

Group	Manufacturer	ARI Score			
		0	**1**	**2**	**3**
W	**Ortho Tecnology**	2	7	0	6
J	**American Orthodontics**	0	1	2	12
K	**Eurodonto**	2	6	2	5
A	**Orthometric**	2	2	2	9

p = 0.024. 0 indicates no adhesive remained on the tooth; 1 less than 50% of the adhesive remained on the tooth; 2 more than 50% of the adhesive remained on the tooth; 3 all adhesive remained on the tooth.

The differences in the mean values among the groups are not great enough to exclude the possibility that the difference is due to random sampling variability. There was no statistical difference among the groups. Most of the results presented a index of 3 in the ARI, which means all the adhesive remaining on the tooth after debonding. There was no bracket breakage the shear bond strength test and also no enamel damage during the process of debonding.

DISCUSSION

When selecting a bracket for an orthodontic treatment we have to consider that the bracket has to have a bond strength that is high enough to endure all treatment without debonding easily but not so high that it can damage the dental tissue during debonding. Studies found that a minimum bond strength force of 5.9 to 7.8 MPa have a proper adhesion for successful bonding. When considering a shear bond strength that can cause fractures and enamel damage, a shear bond strength of 13.5 MPa was reported[15]. Considering that, all groups tested obtained an adequate bond strength. The minimum bond strength found was 7.71 MPa in group A (Orthometric) and the maximum found was 12.82 MPa in group W (Ortho Tecnology).

In our study none of the ceramic brackets fractured during debonding. Merrill SW, Oesterle LJ, Hermesch CB (1994)[16] found that 30% of bracket fracture and one instance of enamel damage during the process of shear bond strength. But it is important to consider that this result was obtained with monocrystalline ceramic brackets that had chemical retention. That can be interpreted that the newer generation of ceramic brackets, with mechanical retention, fracture much less than the older with chemical adhesion. This can be sustained with the study made by Suliman SN, et al (2015)[17], that found only 1 out of 19 monocrystalline ceramic brackets that were tested fracture.

Most of the monocrystalline ceramic bracket failures were in the interface between the bracket and the adhesive score 3 of ARI. Harris AMP, Joseph VP, Rossouw PE (1992)[11] and Suliman SN, et al (2015)[17] found similar results as ours. That diverges from what Viazis AD, Cavanaugh G, Bevis RR (1990)[18] concluded, which is that the mechanical bonds failed primarily within the adhesive itself when debonded with shear strength. Maybe the improvement of the mechanical retention instead of chemical retention for the ceramic brackets changed some patterns found in the past. The failure interface that we found now can be considered adequate because it is a less critic interface when it comes to damaging the enamel. Meanwhile, it means that the orthodontist will have to spend more time cleaning the enamel surface after debonding the brackets, but less chances of enamel damage.

Even though most brackets presented an ARI score of 3, 46.6% of the group W (Ortho Technology) had a score 1 of ARI and 40% in group K (Eurodonto), which means that less than 50% of the adhesive remained on the tooth surface. Although that result is more critical to enamel damage, no enamel damage was seen in the specimens of these groups.

For the safe use of these brackets we have to study each case individually. As Bishara (1999)[19] said, we should always use these brackets with caution to prevent contact with the opposing teeth and consequent enamel damage since its hardness is higher than the enamels. If the patient has an increased overbite we have to correct it before bonding these brackets on the mandibular teeth.

Further studies to analyze microscopically the enamel before bonding the brackets, soon after debonding and cleaning the enamel have to be considered to certify that there is no enamel damage caused by this type of ceramic brackets. As much as macroscopic analyses could detect, no damage of the enamel surface was seen in the present study.

CONCLUSION

All brands of monocrystalline ceramic brackets tested presented an adequate bond strength for an orthodontic treatment. Most brackets debonded in the interface between adhesive and bracket, no macroscopic enamel damage was detected and none of the brackets fractured during the shear bond strength test.

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4 CONSIDERAÇÕES FINAIS

Todas as marcas comerciais de bráquetes cerâmicos monocristalinos estudadas apresentaram resistência de união ao cisalhamento adequadas para o tratamento ortodôntico. A maioria descolou na interface entre o adesivo e o bráquete e nenhum dano ao esmalte foi percebido bem como não houve fratura dos bráquetes durante o processo de cisalhamento.

Os bráquetes cerâmicos monocristalinos das marcas comerciais estudadas podem ser considerados uma alternativa segura que podem substituir os bráquetes metálicos quando houver a demanda por um aparelho ortodôntico estético.

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ANEXO A – CARTA DE DOAÇÃO DE DENTES BOVINOS PARA A REALIZAÇÃO DO ESTUDO

BOA ESPERANÇA
AGROINDÚSTRIA

ALLBANI

Boa Esperança Agroindústria Ltda.

91.283.069/0001-25

Santo Antônio da Patrulha - RS

Santo Antônio da Patrulha, 05 de janeiro de 2015.

A Boa Esperança Agroindústria Ltda., realizou a doação de 20 mandíbulas bovinas à equipe de Ortodontia da Faculdade de Odontologia da Universidade Federal do Rio Grande do Sul para a utilização dos dentes em atividade de pesquisa. Afirmamos que tais mandíbulas são provenientes de animais de corte, abatidos exclusivamente para consumo da carne, e que seriam utilizadas na fabricação de farinha de carne, como subprodutos.

Atenciosamente,

(Daniela de Moraes Adam – CPF 017.868.450-32)

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ANEXO B – REQUISITOS DE FORMATAÇÃO DA REVISTA PARA A REALIZAÇÃO DO ARTIGO

Information for Contributors

Please organize and enter your Original Article manuscript using the following headings (Case reports and other types of articles may vary):

- **ARTICLE FILE**

  Articles must be original and written in clear English. The total article file must be entered as one document and must contain the Title, Abstract, Text References and Figure Legends. The article file must not exceed a maximum of 3500 words. To determine the number of words in your document, go to the toolbar, click on tools and then click on word count.

  Please enter only the following items in the article file:

  - **Title** of the manuscript
  - **Abstract** - *The Angle Orthodontist* is using a structured abstract which must be limited to 250 words. The abstract should conform to the following outline and not contain an introduction, literature review or discussion.

    ABSTRACT
    Objective: List the specific goal(s) of the research.
    Materials and Methods: Briefly describe the procedures you used to accomplish this work. Leave the small details for the manuscript itself.
    Results: Identify the results that were found as a result of this study.
    Conclusion: List the specific conclusion(s) that can be drawn based on the results of this study.

  - **Manuscript text -** Please remove all references to the author's identity or institutions as manuscripts are peer reviewed anonymously. An original article text will contain the following in order:

    INTRODUCTION - This section states the purpose of the research and includes a brief summary of the literature describing the current state of the field.

    MATERIALS AND METHODS -This section states exactly what was done and should enable a reader to replicate the work. Materials or methods described elsewhere in the literature can be referenced without repeating these details. Identify teeth using the full name of the tooth or the FDI annotation. If human subjects or animals were involved in the work, this section must contain a statement that the rights of the human or animal subjects were protected and approval was obtained from an identified institutional review board, or its equivalent.

    RESULTS - This section should describe the objective findings without any comment on their significance or relative importance. Cite all tables and figures in sequential order in the text.

    DISCUSSION - Only this section allows you freedom to interpret your data and to give your opinion of the value of your findings relative to previous work. All opinions must be limited to this section.

    CONCLUSION - This section states what conclusions can be drawn specifically from the research reported. Bullet points are preferred. Do not repeat material from other sections..

REFERENCES - References cited must refer to published material. Number references consecutively in order of their appearance in the manuscript using superscript and Arabic numerals. References to "personal communication" or unpublished theses are not acceptable. The style and punctuation of references should strictly conform to *American Medical Association Manual of Style: A Guide for Authors and Editors,* 9th ed (Baltimore, Md: Williams & Wilkins; 1998). Consult previous issues of The Angle Orthodontist for guidance (Available at http://www.angle.org).

FIGURE LEGENDS - All figures must be numbered sequentially in the manuscript and a legend for each figure must appear in this section.

- **TABLE FILES**

Each table must be in WORD or EXCEL format and entered as a separate file. Each table must have its own legend accompanying it, numbered with Arabic numerals and sequentially referred to in the text. All abbreviations used in the table must be defined in a footnote. Use * *P*=.05; ** *P*=.01; *** *P*=.001; ****P=.0001 as needed. Tables cannot be in pictorial or image formats. Pictorial or image formats are figures and must be entered as figures.

- **FIGURE FILES**

Each figure must be of sufficient resolution for high quality publication usually in TIFF or EPS format. All images need to be at 300 DPI when the figure is of the size to be used in publication.

If you enter a large image at 300 DPI and reduce it to a much smaller size for publication, this will increase the DPI and the image will be very heavy and slow to open electronically. If you enter a small image (such as a 35 mm picture) and plan to enlarge it for publication, it needs to be entered at more than 300 DPI since enlargement will only reduce the resolution.

Figures in WORD or presentation software such as PowerPoint, Corel Draw or Harvard Graphics do not contain sufficient resolution for publication and will not be accepted. Authors will be charged for publication of figures in color.