Universidade Estadual de Campinas
Faculdade de Odontologia de Piracicaba

FÁBIO LOURENÇO ROMANO
Cirurgião-Dentista

AVALIAÇÃO CLÍNICA E LABORATORIAL DA COLAGEM DE BRÁQUETES METÁLICOS COM COMPÓSITOS ORTODÔNTICOS

Tese apresentada à Faculdade de Odontologia de Piracicaba, Universidade Estadual de Campinas/UNICAMP, para obtenção do título de Doutor em Radiologia Odontológica, Área de Concentração em Ortodontia.

Orientadora: Profa. Dra. Maria Beatriz Borges de Araújo Magnani
Co-orientador: Prof. Dr. Lourenço Correr Sobrinho

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Banca Examinadora: Antônio Carlos de Oliveira Ruellas, José Tarcísio Lima Ferreira, Simonides Consani, Vânia Célia Vieira de Siqueira, Maria Beatriz Borges de Aráujo Magnani

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PROFa. DRa. MARIA BEATRIZ BORGES DE ARAUJO MAGNANI

PROF. DR. ANTONIO CARLOS DE OLIVEIRA RUELLAS

PROF. DR. JOSÉ TARCÍSIO LIMA FERREIRA

PROF. DR. SIMONIDES CONSANI

PROFa. DRa. VANIA CELIA VIEIRA DE SIQUEIRA

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pela adição de novos fatos e
pela simplificação do que já existe.
(C. Bernard)

LISTA DE ABREVIATURAS E SIGLAS

TPSEP - Transbond Plus Self Etching Primer
TPCC - Transbond Plus Color Change
IRA - Índice de Remanescente de Adesivo
ARI - Adhesive Remnant Index
ANOVA - Análise de Variância
SEP - Self Etching Primer
MPa - MegaPascal
N - Newton
kgf - Quilograma-força
PVC - Policloreto de vinila rígido
mm - Milímetro
mm^2 - Milímetro quadrado
% - Porcento
mW/cm^2 - Miliwatt por centímetro quadrado
mm/min. - Milímetro por minuto
°C - Graus Celsius
GL - Graus de liberdade
SQ - Soma dos Quadrados
QM - Quadrado médio
P - Probabilidade

LISTA DE FIGURAS

Capítulo 1:

Capítulo 2:

Apêndice

LISTA DE TABELAS

Capítulo 1:

Capítulo 2:

Apêndice:

RESUMO

O objetivo neste estudo foi avaliar clinicamente e em laboratório, a taxa de descolagem e a resistência ao cisalhamento de bráquetes metálicos colados com compósitos ortodônticos. O experimento clínico consistiu de 20 pacientes (10,5-15,1 anos de idade), que procuraram tratamento ortodôntico corretivo. Nestes pacientes foram colados bráquetes de 2° pré-molar a 2° pré-molar no arco superior e inferior com os sistemas adesivos: Concise Ortodôntico, Transbond XT convencional, Transbond XT sem agente de união e Transbond XT em esmalte preparado com ácido-primer Transbond Plus Self Etching Primer (TPSEP). Todos os sistemas foram utilizados em todos os pacientes, em rodízio pelos quadrantes, sendo que, a mesma sequência de colagem se repetiu em cada cinco pacientes. Arcos iniciais foram inseridos uma semana após a colagem dos bráquetes. Os pacientes foram avaliados durante seis meses para quantificar o número de bráquetes descolados. Ao final do período de observação ocorreram 8 descolagens com Concise Ortodôntico, 2 com Transbond XT convencional, 9 com Transbond XT sem agente de união e 1 com TPSEP + Transbond XT. Pelo Método de Kaplan-Meier foram encontradas diferenças estatísticas significantes na taxa de descolagem entre os materiais (P=0,0198) e o teste Logrank identificou estas diferenças. O Transbond XT convencional e TPSEP + Transbond XT foram estatisticamente superiores (apresentaram menos descolagens) em relação ao Concise Ortodôntico e Transbond XT sem agente de união (P<0,05). Entre os materiais Transbond XT convencional e TPSEP + Transbond XT não foram encontradas diferenças estatísticas significantes, assim como, entre Concise Ortodôntico e Transbond XT sem agente de união (P>0,05). O experimento laboratorial teve como objetivo avaliar a resistência ao cisalhamento de bráquetes metálicos colados com o novo compósito ortodôntico Transbond Plus Color Change (TPCC, 3M Unitek) em diferentes preparações de esmalte e analisar após a descolagem o Índice de Remanescente de Adesivo (IRA). Foram utilizados 72 pré-molares humanos divididos em seis grupos (n=12). No Grupo 1 (controle) foi utilizado o compósito Transbond XT convencionalmente. Nos demais grupos (2 a 6) utilizou-se o TPCC nas seguintes condições de esmalte: ácido fosfórico e XT primer; ácido-primer TPSEP; somente ácido fosfórico; ácido fosfórico, XT primer e saliva; TPSEP e saliva, respectivamente. Após a colagem dos bráquetes e fotoativação, os corpos de prova foram armazenados em água destilada em estufa a 37°C por 24 horas. Em seguida, os bráquetes foram carregados em máquina Instron à velocidade de 0,5 mm/min. e o IRA avaliado em lupa estereoscópica. Os valores médios de resistência ao cisalhamento (MPa) foram: Grupo 1- 24,6; Grupo 2-18,7; Grupo 3-17,5; Grupo 4-19,7; Grupo 5-17,5 e Grupo 6-14,8. Os dados foram submetidos à ANOVA e ao teste de Tukey (5%). O Grupo 1 apresentou maior média e diferiu estatisticamente dos grupos 3, 5 e 6 ($P<0,05$) e sem diferença estatística significante em relação aos grupos 2 e 4 ($P>0,05$). Entre os grupos 2, 3, 4, 5 e 6 não foram encontradas diferenças estatísticas significantes ($P>0,05$). A colagem de bráquetes com TPCC apresentou valores comparáveis ao Transbond XT convencional e o tipo de preparo de superfície não influenciou esta adesão.

Palavras-chave: resinas compostas, resistência ao cisalhamento, bráquetes ortodônticos, ortodontia.

ABSTRACT

The aim of this study was to assess clinically and laboratory the bracket failure rate and shear bond strength of metallic brackets bonded with orthodontic composites. The *in vivo* study consisted of 20 patients aged between 10.5 to 15.1 years old who had sought corrective orthodontic treatment. Brackets were bonded of the second premolar – second premolar to their upper and lower arches using the adhesive systems: Orthodontic Concise, conventional Transbond XT, Transbond XT without primer, and Transbond XT applied to enamel etched with Transbond Plus Self-etching Primer (TPSEP). All the adhesive systems were used in all patients on a quadrant-rotation basis by repeating the same bonding sequence in every 5 patients. Initial archwires were inserted a week after the brackets bonding. The patients were evaluated during six months in order to quantify the number of brackets failure regarding each adhesive system. At the end of the observation period, 8 brackets failure rates were observed for Orthodontic Concise, 2 for conventional Transbond XT, 9 for Transbond XT without primer, and 1 with Transbond XT + TPSEP. By using the Kaplan-Meier methods, statistically significant differences were found between the materials (p=.0198), and the Logrank test identified these differences. It was observed that conventional Transbond XT and Transbond XT + TPSEP were statistically superior (fewer debonded brackets) compared to Orthodontic Concise and Transbond XT without primer (P<.05). However, no statistically significant differences were found between conventional Transbond XT and TPSEP + Transbond XT as well as between Orthodontic Concise and Transbond XT without primer (P>.05). The *in vitro* study aimed at assessing the shear bond strength of metallic brackets bonded to different enamel surfaces using the Transbond Plus Color Change composite (TPCC, 3M Unitek) as well as to analyse the Adhesive Remnant Index (ARI). Seventy-two human premolars were used for study, with all samples being divided into six groups (n =12). In Group 1 (control), Transbond XT composite was conventionally used. In other groups (2-6), TPCC was used under the following enamel conditions: phosphoric acid and XT primer; TPSEP; phosphoric acid only; phosphoric acid, XT primer and saliva; and TPSEP and saliva, respectively. After bracket bonding and photo-activation, the samples were stored in distilled water for 24 hours at 37°C in a stove. Next, the brackets were debonded by using an Instron machine at crosshead speed of 0.5 mm/min, and the ARI were evaluated by using a stereoscopic magnifying glass. The mean shear strength values (MPa) were the following: Group 1, 24.6; Group 2, 18.7; Group 3, 17.5; Group 4, 19.7; Group 5, 17.5; and Group 6, 14.8. Data were submitted to both ANOVA and Tukey's test (5%). Group 1 was found to be statistically superior to Groups 3, 5, and 6 ($P<.05$), with no statistically significant difference compared to Groups 2 and 4 ($P>.05$). No statistically significant differences were found between Groups 2, 3, 4, 5 and 6 ($P>.05$). The bracket bonding using TPCC composite showed values comparable to the conventional Transbond XT, and the type of enamel preparation had no influence.

Keywords: composite resins, shear strength, orthodontic brackets, orthodontics.

SUMÁRIO

INTRODUÇÃO

A partir das décadas de 1950 e 1960 os acessórios ortodônticos começaram a ser fixados diretamente ao esmalte dentário (Buonocore, 1955; Newman, 1964; 1965). Com este advento, a montagem do aparelho ortodôntico que era realizada através de bandas em todos os dentes foi gradualmente substituída pela colagem, o que trouxe inúmeros benefícios ao paciente e ortodontista (Bishara *et al*., 1975).

O procedimento de colagem sofreu modificações ao longo dos anos, novos materiais foram desenvolvidos, tornando a técnica direta mais simples e rápida. Paralelamente, as propriedades adesivas dos materiais foram melhoradas, aumentando a adesão do acessório ao dente (Jobalia *et al*., 1997; Bishara *et al*., 1998; Meehan *et al*., 1999; Littlewood *et al*., 2000; Hobson *et al*., 2001; Elíades *et al*., 2002; Kula *et al*., 2003).

Atualmente, os compósitos são os produtos mais utilizados para colagem de acessórios ao esmalte, sendo constituídos principalmente de BIS-GMA (Bisfenol A-glicidilmetracrilato), silano, partículas de carga e pequenas quantidades de aditivos (Anusavice, 1998). Estes materiais apresentam-se auto e fotopolimerizáveis, e necessitam de adequado preparo da superfície do esmalte para que ocorra retenção do acessório ortodôntico (Zachrisson, 2000). Este preparo deve ser realizado através de profilaxia, condicionamento ácido e aplicação do agente de união. Somente, após estes passos, o compósito é colocado na base do acessório e a colagem propriamente dita é efetuada (Bishara *et al*., 1999; Webster *et al*., 2001; Bishara *et al*., 2002; Romano & Ruellas, 2003).

Apesar de ter sido simplificada, a técnica de colagem com compósitos de maneira convencional ainda demanda elevado tempo de procedimento, necessidade de manter o campo operatório seco e habilidade do profissional, principalmente quando são utilizados compósitos ativados quimicamente (Arnold *et al*., 2002; Schaneveldt & Foley, 2002; Buyukyilmaz *et al*., 2003).

Há alguns anos foram desenvolvidos os agentes autocondicionantes ou Self Etching Primers (SEPs) para preparo da superfície do esmalte previamente a colagem. Estes materiais conjugam ácido e primer em um só produto (Miller, 2001) e necessitam de menor tempo de procedimento devido ao menor número de passos clínicos (White, 2001) facilitando o controle do campo operatório. Estes SEPs apresentaram bons resultados em estudos laboratoriais (Cacciafesta *et al.,* 2003; Dorminey *et al*., 2003; Grubisa *et al*., 2004; Vicente *et al*., 2005; Romano *et al*., 2005; 2006) e clínicos (Pandis *et al*., 2005; Manning *et al*., 2006; Pasquale *et al*., 2007; Elekdag-Turk *et al*., 2008; Reis *et al*., 2008) porém, algumas de suas características como biocompatibilidade e estabilidade de cor, ainda não são conhecidas.

Recentemente foi desenvolvido um novo compósito ortodôntico – Transbond Plus Color Change (TPCC, 3M Unitek, Monrovia) que possui propriedade de mudança de cor após a fotoativação para facilitar a remoção dos excessos e presença de flúor na fórmula. Apesar da indicação para uso clínico todo produto lançado no mercado necessita ser testado em experimentos laboratoriais e principalmente clínicos para comprovar sua eficácia e eficiência, respectivamente. Estes testes devem ser realizados com a finalidade de quantificar o valor de adesão e também avaliar se o material é capaz de resistir aos esforços mastigatórios, às forças oclusais e a mecânica ortodôntica (Reynolds, 1975).

Avaliar se um material de colagem é apropriado para uso clínico, não requer somente conhecer suas propriedades adesivas, mas também verificar, se suas características não causam dano ao paciente, como manchas e fraturas. Desta forma, antes de um produto ser utilizado no paciente, deve-se conhecê-lo amplamente, principalmente suas qualidades adesivas *in vitro* e *in vivo.*

Assim, os objetivos do presente trabalho foram:

1- Avaliar clinicamente por um período de 6 meses a taxa de descolagem de bráquetes metálicos colados com os compósitos Concise Ortodôntico e Transbond XT, sendo este último em diferentes condições de superfície de esmalte, ou seja, de maneira convencional, sem agente de união e com o ácido-primer TPSEP. Comparou-se também o número de bráquetes descolados entre os arcos, regiões, lados e quadrantes da arcada dentária.

2- Avaliar *in vitro* a resistência ao cisalhamento de bráquetes metálicos colados com o novo compósito TPCC em diferentes condições de esmalte: convencional, com TPSEP, sem agente de união e também em superfícies contaminadas com saliva. Avaliou-se também após a descolagem o IRA.

Capítulo 1:

Clinical Evaluation of the Failure Rates of Brackets Bonded with Different Adhesive Systems*

Abstract

In order to assess *in vivo* bonding of metallic orthodontic brackets with different adhesive systems, 20 patients (10.5-15.1 years old) who had sought corrective orthodontic treatment were evaluated. Brackets were bonded second premolar - second premolar to their upper and lower arches using: Orthodontic Concise, conventional Transbond XT, Transbond XT without primer, and Transbond XT + Transbond Plus Self-etching Primer (TPSEP). All patients received the 4 adhesive systems in a rotative manner beyond the four dental quadrants, so that each group of 5 patients have received the same bonding sequence. Initial archwires were inserted a week after the brackets bonding. Through six months observation period the number of brackets failure rates in each system was quantified. By using the Kaplan-Meier methods, statistically significant differences were found between the materials (p=.0198), and the Logrank test identified these differences. The failure rate was: 8%- Orthodontic Concise, 2%- conventional Transbond XT, 9%- Transbond XT without primer, and 1%- Transbond XT + TPSEP. The bond failure rate at the end of the period was statistically superior for the systems: Conventional Transbond XT and Transbond XT + TPSEP versus the others (p<.05). In conclusion, in the period of observation, Conventional Transbond XT and Transbond XT + TPSEP showed better adhesive qualities.

Keywords: composite resins, orthodontic brackets, orthodontics.

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1 - Introduction

Many commercially available orthodontic bonding materials have been experimentally evaluated in laboratories,[1-4] but not all were clinically tested to confirm their efficiency and effectiveness. Despite the lack of clinical evaluation, these materials are commonly used by orthodontists for inserting orthodontic appliances.

Amongst the most widely used materials for bonding orthodontic accessories directly to dental enamel, we may cite the composites that despite proving adequate adhesion also require dry working field and step-by-step clinical technique.[5,6] For bonding brackets using composites conventionally, the enamel surface must be adequately prepared through prophylaxis with pumice stone, water, washing and drying, conditioning with 37% phosphoric acid for 15-30 seconds, washing and drying again, and finally, application of the bonding agent accompanying the composite used.

The Orthodontic Concise (3M Brazil, Sumaré, Brazil) and Transbond XT (3M Unitek, Monrovia, USA) composites, when used according to the manufacturer's recommendations, require their primers (respectively, fluid resins A and B, and XT primer) be used. There is controversy about the use of primers, since some authors did not find differences in the adhesion of orthodontic accessories to enamel with or without the previous use of them.[7,8] This material moistens and penetrates the enamel and protect the etched tooth surface that will not suffer decalcification caused by plaque and food residues.[7] Despite some advantages, avoiding such a bonding procedure would decrease chair time, keep the working field dry, and possibly reduce the bonding failure caused by contamination or humidity.

The self-etching primers (SEPs), which combine acid and primer in one solution, have been recently developed.[9-11] SEPs are easy to be handled and can be applied even to contaminated surfaces, thus providing comfort for patient and short-time visits.[11,12] The Transbond Plus Self-Etching Primer (TPSEP, 3M Unitek, Monrovia, USA) was tested in several laboratory[3,4,9,13,14] and clinical[10,15-31] experiments, achieving good adhesive results. Some studies have quantified the number of debonded brackets using TPSEP as enamel conditioning agent before using Transbond XT for the bonding procedure[18,24,32], while others have compared different self-etching agents and primers.[10,18,19,21,25,28,29] Nevertheless, no study has assessed four different adhesive systems in the same patient by using quadrant variations.

The purpose of the present study was to perform a 6-month clinical assessment of the failure rate of brackets bonded with Orthodontic Concise, conventional Transbond XT, Transbond XT without primer, and Transbond XT + TPSEP. The number of brackets failure was also compared between dental arches, regions, sides, and quadrants.

2 – Materials & Methods

This research protocol was approved by the Piracicaba Dental School Research Ethics Committee, State University of Campinas/UNICAMP, under protocol number 116/2008.

A total of 42 patients were recruited from the waiting list of the Orthodontic Clinic at the Piracicaba Dental School, however, only twenty patients, 13 females and 7 males with aged between 10.5 and 15.1 years old who met the inclusion criteria were selected. Only those individuals needing corrective orthodontic treatment but who had never been submitted to any type of orthodontic therapy were included in the study. The exclusion criteria were need for ortho-surgical treatment, tooth extractions for correction of malocclusion, presence of gold or ceramic dental crowns, presence of resin, restorations with amalgam or composite, congenital enamel defects, missing tooth, and craniofacial anomalies. Sex, age, race and malocclusion differences were ignored. The details of sample size, malocclusion types, number of brackets bonded with each adhesive system and patient distribution by gender and age are presented in Table 1.

Table 1: Sample characteristics

	Number	%
Number of patients	20	-
Distribution of patients by gender		
Male	7	35
Female	13	65
Distribution by age		
<11	3	15
11-12	8	40
12-13	6	30
13-14	1	5
14-15	1	5
>15	1	5
Number of brackets	400	-
Distribution of brackets by adhesive system		
Orthodontic Concise	100	25
Conventional Transbond XT	100	25
Transbond XT without primer	100	25
Transbond XT + TPSEP	100	25
Distribution by malocclusion		
Class I	8	40
Class II	11	55
Class III	1	5

Selected patients received corrective orthodontic treatment with fixed appliance placed in upper and lower arches using the Edgewise technique. A total of 400 orthodontic brackets (Morelli, Sorocaba, Brazil), 20 in each patient, were bonded to upper teeth 15, 14, 13, 12, 11, 21, 22, 23, 24, and 25 and lower teeth 35, 34, 33, 32, 31, 41, 42, 43, 44, and 45. In the first and second molars orthodontic bands (Morelli, Sorocaba, Brazil) were attached with glass-ionomer cement (Ketac-Cem, 3M ESPE, St. Paul, USA).

Prior to the bracket bonding procedures, a lip and cheek retractors was placed as well as all the buccal surfaces were cleaned with a rubber cup and fluoride-free pumice stones (S.S. White, Petropolis, Brazil) and water for 10 seconds in each tooth at low rotation; washing and drying took the same period of time. Next, cotton rolls were used to isolate and keep the working field dry. Table 2 lists the four adhesive systems used to bond the brackets.

Table 2: Adhesive systems and bonding procedures.

Adhesive systems	Bonding procedures
Orthodontic Concise	Acid etched, manipulation, and application of fluid resins (A e B), gentle air jet, manipulation of pastes A and B of Orthodontic Concise composite, application on the bracket base for bonding
Conventional Transbond XT	Acid etched, application of XT primer, gentle air jet, application of Transbond XT composite on the bracket base for bonding
Transbond XT without primer	Acid etched, application of Transbond XT composite on the bracket base for bonding
Transbond XT with primer-acid	Application of TPSEP*, application of Transbond XT composite on the bracket base for bonding

*TPSEP – Transbond Plus Self Etching Primer

With regard to Orthodontic Concise composite (3M Brazil, Sumaré, Brazil), conventional Transbond XT composite (3M Unitek, Monrovia, USA), and Transbond XT without primer, the dental enamel was previously etched with 37% phosphoric acid (Dentsply, Petropolis, Brazil) for 15 seconds, followed by washing and drying for the same period of time. However, TPSEP (3M Unitek, Monrovia, USA) was used for conditioning the enamel surface prior to Transbond XT composite according to the manufacturer's recommendations, that is, the material was rubbed onto the enamel surface for three seconds and then air jet was gently applied.

With regard to the bonding procedure, the brackets containing the composites in their base were pressed against the enamel surface by means of a pair of nippers (Orthoply, Philadelphia, USA), positioned in relation to the tooth, and the material excess removed with a small scaler (Duflex, Juiz de Fora, Brazil).

The bracket bondings with Transbond XT were light cured for 40 seconds (10 seconds for each face: mesial, distal, incisal or occlusal, and gingival by using a halogen light XL 2500 device (3M ESPE, St. Paul, USA) with irradiance of 500mW/cm^2 at a distance of 1mm from the bracket. The light intensity was regularly gauged with a curing radiometer (Demetron, Danbury, USA).

The adhesive systems were allocated by split-mouth method: the mouth of each patient was divided into four quadrants with each system being used in the one quadrant of the dental arch according to bonding sequence. Each bonding sequence was repeated in every five patients to assure an equal distribution between the quadrants and reduce bias because of patient chewing or parafunctional preferences (Diagrams 1 to 4, Figure 1).

Diagram 1

UR	Orthodontic Concise	Conventional Transbond XT	UL
LR	Transbond XT + TPSEP	Transbond XT without primer	LL

Diagram 2

UR	Transbond XT + TPSEP	Orthodontic Concise	UL
LR	Transbond XT without primer	Conventional Transbond XT	LL

Diagram 3

UR	Transbond XT without primer	Transbond XT + TPSEP	UL
LR	Conventional Transbond XT	Orthodontic Concise	LL

Diagram 4

UR	Conventional Transbond XT	Transbond XT without primer	UL
LR	Orthodontic Concise	Transbond XT + TPSEP	LL

Quadrants: Upper right (UR); Upper left (UL); Lower right (LR); Lower left (LL).

Figure 1: Distribution of adhesive systems in the four quadrants

The brackets were bonded in all patients by only one operator in order to eliminate interexaminer variation during a single visit. Immediately after the bonding procedures, the patients were instructed about the maintenance care of their appliances, oral hygiene, and type of alimentation to be avoided, as hard foods can damage the orthodontic accessories. The lower arch brackets were bonded in such a way as to avoid precocious contact. One week after, 0.012-inch nickel-titanium alloy archwires were placed in all patients with elastomerics modules. At subsequent appointments, the archwire sequence was 0.016”, 0.018”, 0.20”, 0.018 x 0.025” and 0.019 x 0.025”. The patients were seen every 21 days for checking bonding failures and for evaluating the corrective orthodontic treatment.

During this 6-month evaluation, any bond failure was recorded on a data collection sheet on the day the patient attended with the breakage. The first bond failure for each tooth was recorded by date and tooth number. A failure was regarded as an all or none occurrence, and subsequent failures of bonding for that same tooth were noted, but not included in the study. In the same appointment, the failure bracket was replaced using the same adhesive and bonding technique. The patients were still under treatment according to previous orthodontic treatment planning. The treatment duration was established individually for each patient based on the malocclusion characteristics involved.

Statistical Analysis

The categorical variables were expressed as percentage by using Fisher's test or chi-square test for tendency and independence.

Positional characteristics and bond status were compared using chi-square tests, t-tests, and analysis of variance (ANOVA) as applicable. Crude incidence rates and 95% confidence intervals were calculated using time-to-event methods. The proportion of brackets remaining free of failure at any time during follow-up was calculated using the Kaplan-Meier method. For all survival analyses, the follow-up time was defined as the period from entry into the study to the first bond failure or up to the time an individual left the study. We compared the Kaplan-Meier curves using Logrank test.

Statistical significance of 5% ($p<.05$) was adopted in all tests. The STATA Intercool software, version 9.2, was used for statistical analyses and graph construction.

3 – Results

At the end of the 6-month evaluation period, 20 brackets (5%) out of a total of 400 had failure.

Statistically significant differences were observed (p=.0198) when comparing the number of brackets failure between the four adhesive systems. Amount of bond failure rates, risk over time, incidence rate, and confidence interval (95%) regarding each adhesive system are described in Table 3.

Table 3: Amount of failure rates, incidence rate, and confidence interval (95%) regarding each adhesive system

Adhesive systems	Failure rates	Incidence rate	Confidence interval	Logrank test
1- Orthodontic Concise	8	0.00042	0.000168 – 0.0008653	b
2- Transbond XT (conventional)	2	0.0001126	0.0000136 – 0.0004038	a
3- Transbond XT without primer	9	0.0005402	0.000247 – 0.0010254	b
4- Transbond XT + TPSEP	1	0.0000561	1.42e- 06 – 0.0003126	a

Equal letters = no statistically significant difference

Conventional Transbond XT and Transbond XT + TPSEP adhesive systems were found to be statistically superior (fewer brackets failure) to Orthodontic Concise and Transbond XT without primer (p<.05). On the other hand, no statistically significant differences were observed between conventional Transbond XT and Transbond XT + TPSEP (p>.05) as well as between Orthodontic Concise and Transbond XT without primer (p>.05). Figures 2 show such differences according to the Kaplan-Meier survival curve.

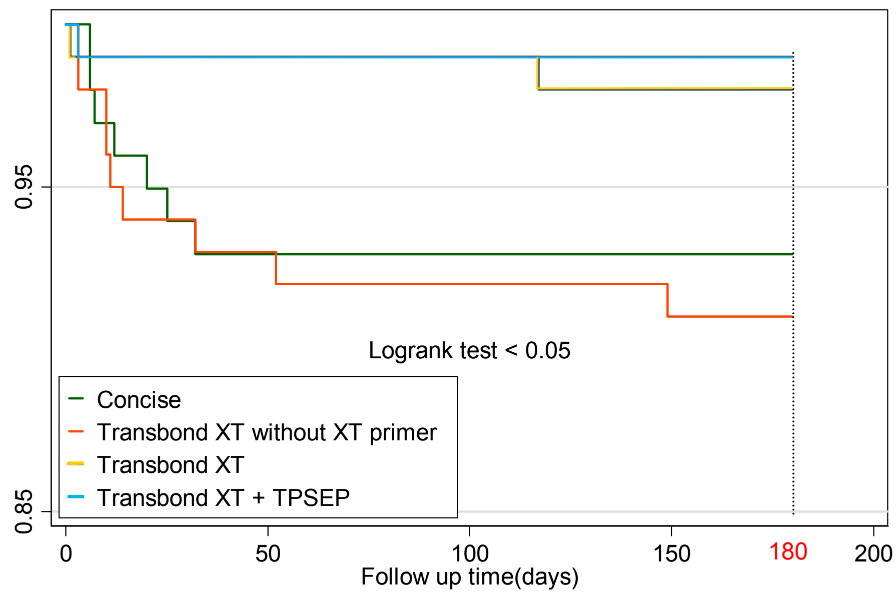

Figure 2: Kaplan-Meier survival curve for brackets bonded using different adhesive systems

By analysing the number of bond failures in both dental arches, it was observed 11 failures (55%) in the upper arch and 9 in the lower arch (45%) during the same evaluation period, with no statistically significant differences (p=.646). The upper teeth affected by these bracket failures were the left and right second premolars with 5 events each, whereas the left first premolar had only 1 debonding. In the lower arch, the teeth affected were the left and right second premolars, the left central incisor, and the right lateral incisor with, respectively, 5, 2, 1, and 1 bracket failure.

By comparing the failure rate between the regions of dental arch, it was observed a statistically significant difference (p<.001) as 2 failurs (10%) were observed in the anterior region and 18 (90%) in the posterior region. The majority of the bond failure rates occurred on the left side (n = 12; 60%) compared to the right side (n= 8; 40%), but such a difference was not statistically significant (*p*=.359).

Of the 400 brackets being used, 100 were bonded with one of the four adhesive systems, 25 in each different quadrant for every 5 patients. No statistically significant differences were found between quadrants and adhesive systems (*p*=.738). Considering all patients, 5 bond failures occurred in the upper right quadrant, 6 in the upper left quadrant, 3 in the lower right quadrant, and 6 in the lower left quadrant.

4 – Discussion

The majority of orthodontic bonding materials available for clinical use have been tested *in vitro* only. Of course, laboratory essays for assessing these materials under ideal conditions are crucial as an initial test, mainly to quantify the shear bond strength. However, the experimental bonding procedure differs significantly from the clinical one, which is performed under real conditions and requires both working field and oral cavity components be controlled. This makes the bonding technique difficult, interfering with the quality of adhesion between orthodontic accessory and tooth. Prior to choosing a given dental material, it is crucial to test it in clinical experiments so that its characteristics can be further evaluated.

Studies have assessed the clinical efficacy of bonding materials[15,16,22,23] by quantifying the failure rate regarding either one material,[20,22,24] two materials for two patients,[27,29] two materials for one patient with quadrant variations,[10,18,19,21,25,28,30,31] or even interchanging the materials between teeth.[26] Material variation per quadrants in the same patient was adopted to avoid that external factors such as masticatory force, occlusive interferences, brushing style, anatomy, and type of malocclusion interfered with the adhesive results. The present work adopted the model cited above, but with four adhesive systems

(Orthodontic Concise, conventional Transbond XT, Transbond XT without primer, and Transbond XT + TPSEP) being tested in the same patient. This kind of methodological approach also allows various materials to be tested in a single experiment, thus yielding results that are more comprehensive for the same number of patients. Of the 400 bonded brackets, 20 had debonded during the 6-month period of observation, with 90% of them (18) occurring in the first two months. These results (Figure 2) suggest that clinical studies using shorter evaluation periods can be enough for demonstrating differences in the adhesive materials.

Eight failures (8%) were observed for Orthodontic Concise during the study period. This result was found to be statistically inferior to that of conventional Transbond XT and Transbond XT + TPSEP systems. This inferiority can be explained by the fact that this is a self-curing material requiring a short time to be adequately manipulated and a long time to achieve full setting. As a result, the material is subjected to masticatory forces, and occlusion. The failure rates for Orthodontic Concise found in the present study is very close to that of other works[33,34] assessing this composite clinically, but in a longer period of evaluation (12 months). These results do not exclude the potential use of Orthodontic Concise in the clinical setting.

Currently, Transbond XT composite has been the most common material used as control for *in vitro* [2-4,9,11,13,14] and *in vivo* [26,27,30,31] studies due to its good adhesiveness, easy manipulation, and long working time. This finding was also observed in this experiment since of the 100 brackets bonded with such a material, only two (2%) had failure over the 6-month period, thus corroborating its high adhesiveness to dental enamel.

In addition to the Transbond XT composite used in a conventional manner, this same material was also employed in two different situations for preparing the enamel surface: without primer and with TPSEP. These two different applications lead to procedure simplification and decreased chair time. When

Transbond XT was used without primer, nine bracket (9%) failure were observed – a result statistically inferior to that of Transbond XT conventionally used and Transbond XT + TPSEP, but non-statistically significant in relation to Ortodontic Concise (Table 3 and Figure 2). Despite the advantages cited above, the lack of XT primer resulted in a higher number of brackets debonded and in subsequent failure in protecting the etched area not occupied by the bracket base. This means that Transbond XT system should be preferentially used according to the manufacturer's recommendations.

When enamel preparation was performed using TPSEP, only one bracket failure occurred. This result was statistically superior to that of both Transbond XT without primer and Orthodontic Concise, although no statistically significant difference was found in relation to conventional Transbond XT, thus corroborating the literature[21,23,27,30,31] and indicating Transbond XT + TPSEP as an alternative to the conventional system. However, this result is not supported by others authors[21,36] who found a greater number of failure rates being bonded with Transbond XT + TPSEP. Two studies reported the reverse.[17,26] Such a divergence is possibly due to methodological differences as the materials had been interchanged between patients, quadrants and dental elements. Studies testing identical materials in different populations imply that culturally influenced dietary habits and sex differences can affect the failure rate of brackets in vivo.[18]

With regard to the failure rate, no statistically significant differences in dental arches (upper and lower) were found between the four adhesive systems studied. Some authors[21,25,29,30] have also found similar results, whereas others reported a greater number of debondings in the lower arch possibly resulting from occlusive forces.[10,18,20,27]

In this study, the posterior region had more brackets failures than the anterior region did. Both upper and lower premolars were the most affected by bracket failures, totalizing 90%. This finding was similar to that by Murfitt et al.[25], Manning et al.[27] and Elekdag-Turk et al.[30] suggesting that masticatory forces are more intense in the posterior region and presence of a larger amount of aprismatic enamel in premolars[35]. Nevertheless, such a difference is not corroborated by other studies.[18,25,29]

The number of bond failure rates occurring on the right side (n= 8, 40%) compared to the left side (n= 12, 60%) was not found to be statistically significant in the present study as well as elsewhere.[21,25,27] A few studies have assessed this variable and only one reported statistical difference between the right and left sides of the dental arch.[20,29]

Most of the clinical studies on the failure rate of orthodontic brackets have assessed either 1-2 adhesive systems in the same patient or materials in different quadrants. Only Murfitt et al.[25] made statistical comparisons of failure rates between the quadrants and reported statistical differences. In the present work, however, four different adhesive systems were used on a quadrant-rotation basis and no statistically significant difference was found between the quadrants of dental arch.

5 – Conclusion

1- In the 6-month evaluation period, the highest number of brackets failure occurred with Orthodontic Concise and Transbond XT without primer systems and a few brackets failure from conventional Transbond XT and Transbond XT + TPSEP;

2- It was no statistically significant difference between dental arches (upper and lower), between the dental arch sides (right and left), and between the quadrants. More bracket failures were observed in the posterior region compared to the anterior region.

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Capítulo 2:

Shear Bond Strength of Metallic Brackets with a New Orthodontic Composite After Different Enamel Treatment*

Abstract

Objectives: The aim of this study were to assess the shear bond strength of orthodontic brackets in different enamel surfaces using the Transbond Plus Color Change composite (TPCC-3M Unitek) as well as to analyse the Adhesive Remnant Index (ARI). *Material & Methods*: Seventy-two human premolars were divided in six groups (n=12). Group-1(control), Transbond XT conventional. In other groups (2-6), TPCC was used under the following enamel conditions: phosphoric acid and XT primer; Transbond Plus Self-Etching Primer (TPSEP); phosphoric acid only; phosphoric acid, XT primer and saliva; and TPSEP and saliva, respectively. Twenty-four hours after the bonding, brackets were debonded with an Instron at crosshead speed of 0.5mm/min, and ARI was evaluated by using a stereoscopic magnifying glass. *Results*: The mean shear strength values (MPa) were respectively: 24.6; 18.7; 17.5; 19.7; 17.5; 14.8 for groups 1-6. Data were submitted to both ANOVA and Tukey's test (5%). Group 1 was found to be statistically superior to groups 3, 5, and 6 ($P<.05$), with no statistically significant difference compared to groups 2 and 4 ($P>.05$). No statistically significant differences were found between Groups 2 to 6 ($P>.05$). *Conclusion:* TPCC achieved results comparable to those of conventional Transbond XT, with type of enamel preparation not influencing the shear strength values regarding this composite.

Keywords: composite resins, shear strength, orthodontic brackets, orthodontics

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1 - Introduction

Composites are the most common materials used for bonding dental accessories to enamel directly. Such a preference is due to the adequate adhesive values obtained in laboratory and clinical experiments.[1-4]

To bond brackets using composites conventionally, the enamel surface have to be properly prepared through prophylaxis and etched with phosphoric acid before application of the bonding agent. All these procedures are time-consuming and require more chair time, thus making it difficulty to keep the operatory area dry and increasing the possibility of bracket debonding due to saliva contamination or humidity.[5,6]

In order to simplify the bonding procedures, new bonding systems combining etchant and primer in one solution have emerged – the self-etching primers (SEPs). One of these systems is the Transbond Plus Self-Etching Primer (TPSEP, 3M Unitek, Monrovia, USA), an orthodontic bonding agent whose chemical formula is similar to that of phosphoric acid except for the presence of two chains, which yields a solid matrix.[7-9] TPSEP was tested in several laboratory and clinical experiments as an enamel-etching agent to be used before the bracket bonding procedure, and promising adhesive results were achieved.[2,5,8,10-16]

A new composite – Transbond Plus Color Change (TPCC, 3M Unitek, Monrovia, USA) – has been recently developed and is characterised by its initial pink color aimed at facilitating the removal of excess material, becoming transparent after photo-activation. According to the manufacturer, this material releases fluoride and has hydrophilic characteristics that can be used in contaminated by saliva and moisture surface without decreasing the adhesiveness. Enamel surface preparation for use of this material should be carried out with 37% phosphoric acid and bonding agent (XT primer or MIP – 3M Unitek, Monrovia, USA) or TPSEP only.

The aim of the present study was to assess *in vitro* the shear bond strength of metallic brackets bonded with TPCC under different enamel conditions, that is, conventionally, with TPSEP only, without XT primer, and saliva-contaminated enamel surfaces. The Adhesive Remnant Index (ARI) was also assessed after the bracket debonding.

2 - Material & Methods

Ethical approval for this study was obtained from the Piracicaba Dental School Committee, State University of Campinas/UNICAMP, São Paulo, Brazil with number 128/2008.

Teeth

A total of 72 healthy human upper and lower premolars of the right and left sides were used for study, all presenting intact buccal surface with no restoration, caries, fissure or cracks. In addition, those teeth that had been submitted to previous application of chemical agents or submitted to orthodontic or endodontic treatment were excluded. The teeth were cleaned with periodontal curettes and placed in 0.1% thymol solution for 1 week, then being stored in distilled water at 6^{o}C until sample preparation.

Sample Preparation

The teeth's roots were centrally inserted into PVC tubes (Tigre, Joinville, Brazil) with 20mm in height x 20mm in internal diameter containing self-curing acrylic resin (Jet Classico, São Paulo, Brazil) so that the buccal face of each tooth was perpendicularly positioned in relation to the shearing die's base. The resin excess was removed by using a Le Cron spatula (Duflex, Juiz de Fora, Brazil) so that no resin was left in contact with the crown. In order to assure the correct positioning of the tooth, a glass angle square was placed onto the tooth's buccal face and the upper part of the shearing die.

Bonding Procedures

Prior to the bracket bonding, the buccal face of all teeth was cleaned with a rubber cup and pumice stones (S.S. White, Petropolis, Brazil) and water at low rotation for 10 seconds, washing and drying for the same period of time. The rubber cup was replaced after every five prophylaxis in order to keep standard procedures.

The samples were randomly divided into six groups (n= 12). In Group 1, the brackets were bonded with conventional Transbond XT (control) according to the manufacturer's recommendations (3M Unitek, Monrovia, USA). In Groups 2, 3, 4, 5 and 6, the brackets were bonded to different enamel surfaces by using TPCC (3M Unitek, Monrovia, USA) as describe in Table 1.

Table 1: Experimental Groups

Groups	Enamel preparation	Composite
1	37% phosphoric acid + XT primer*	Transbond XT
2	37% phosphoric acid + XT primer*	Transbond Plus Color Change
3	TPSEP◊	Transbond Plus Color Change
4	37% phosphoric acid	Transbond Plus Color Change
5	37% phosphoric acid + XT primer*, human saliva	Transbond Plus Color Change
6	TPSEP◊, human saliva	Transbond Plus Color Change

*Transbond XT bonding agent and Transbond Plus Color Change
◊ Self etching primer from 3M Unitek

The enamel surfaces from Groups 1, 2, 4 and 5 were conditioned with 37% phosphoric acid gel for 15 seconds, then being washed and dried for an equal period of time using a triple syringe. In Groups 3 and 6, TPSEP was rubbed on the enamel for 3 seconds and air-jet was gently applied soon after. The XT primer used in Groups 1, 2 and 5 was applied to the conditioned enable with a brush and spread over with a gentle air jet.

The saliva used in Group 5 and 6 was collected one hour before its use, being applied onto the enamel surface with a dropper and the excess being removed with air spray, thus keeping the surface contaminated.

Brackets

Seventy-two orthodontic brackets (code 10.30.208, Morelli, Sorocaba, Brazil) with base area of 15.78 mm^2 were centrally positioned onto and pressed against the buccal face of the teeth by using a pair of pliers (Ortoply, Philadelphia, USA). The composite excess was removed with an small scaler.

Composite Photo-Activation

A XL 2500 halogen curing-light device (3M ESPE, St Paul, USA) was employed in all bonding procedures during 40 seconds (10 seconds for mesial, distal, occlusal, and gingival faces) at 500 mW/cm^2 of irradiance and at a distance of 1 mm from the bracket's base. The light intensity for each photo-activation was measured by using a curing radiometer (Demetron, Danbury, USA).

Sample Storage

After the bonding and photo-activation procedures, the samples were stored in distilled water and placed in a stove at 37°C in order to simulate the oral temperature.

Shear Bond Strength Test

After the 24-hour storage period, the brackets were submitted to shear bond strength tests in Instron testing machine (Model 44.11, Canton, USA) at crosshead speed of 0.5 mm/min. with its chisel tip placed onto the enamel/composite interface region. The results were obtained in quilogram forces, converted into Newton and then divided by the bracket's base area (Megapascals).

Adhesive Remnant Index

After the bracket debonding procedures, each enamel surface was evaluated with a stereoscopic magnifying glass (Carl Zeiss, Goettingen, Germany) at 8 times magnification and classified according to the ARI scores established by Artun & Bergland[17] (1984) as follows:

0 - no composite remaining on the tooth;

1 - less than half of the composite remaining on the tooth;

2 - more than half of the composite remaining on the tooth;

3 – all composite remaining on the tooth.

Statistical Analysis

Enamel surface preparation was the factor taken into account regarding the statistical analysis. The shear strength values were submitted to analysis of variance (ANOVA) and Tukey's test at a 5% significance. Kruskall-Wallis test and Student-Newman-Keuls test were used for comparing the ARI scores.

3 - Results

Table 2 shows the mean values obtained from the six groups submitted to shear bond strength testing and statistical analysis as well.

Table 2: Shear bond strength results.

Groups	N	Mean (Standard deviation)	Tukey's test (5%)
1- Transbond XT (conventional)	12	24.6 (5.2)	a
2- TPCC (conventional)	12	18.7 (5.5)	ab
3- TPSEP + TPCC	12	17.5 (4.1)	b
4- TPCC without primer	12	19.7 (4.7)	ab
5- TPCC (conventional) + saliva	12	17.5 (4.0)	b
6- TPSEP + TPCC + saliva	12	14.8 (5.3)	b

Mean expressed in MPa
Equal letters = no statistically significant difference.
TPCC = Transbond Plus Color Change

Analysis of variance (ANOVA) indicated statistically significant difference between the groups (*P*=.002) regarding the shear strength values, which was identified by using Tukey's test. Group 1 was found to be statistically superior to groups 3, 5, and 6 (*P*<.05), but no statistically significant difference was observed in relation to groups 2 and 4 (*P*>.05). Also, no statistically significant difference was found between groups 2, 3, 4, 5 and 6 (*P*>.05). Mean ARI rank for each group and statistical analysis are listed in Table 3.

Table 3: ARI scores and statistical comparison.

Groups	Mean rank	Statistics
1	28.20	a
2	37.54	abc
3	46.08	bc
4	49.91	c
5	24.79	a
6	32.45	ab

Equal letters = no statistically significant difference

The Kruskal-Willis and Student-Newman-Keuls statistical tests identified statistically significant differences between the groups (*P*=.009). These differences were observed between Groups 1 and 3 (*P*=.036); Groups 3 and 5 (*P*=.021); Groups 4 and 5 (*P*=.003), and Groups 4 and 6 (*P*=.041). The great majority of fractures (94.4%) after the bracket debonding occurred at the bracket/composite interface, where some amount of remaining composite could be seen on the enamel. ARI score 1 (less than half of the composite on the tooth) was more predominantly seen in Groups 1, 5 and 6, whereas ARI score 2 (more than half of the composite on the tooth) was more predominant in Groups 2, 3 and 4. ARI score of 0 (no composite remaining on the tooth) was found only in four samples (Figure 1). ARI score 3 (all the composite on the tooth), the ideal situation to be found following the bracket debonding, was observed in 17 samples, namely, three in Groups 1 and 2, four in Group 3, five in Group 4, and only one in Groups 5 and 6 (Figure 1).

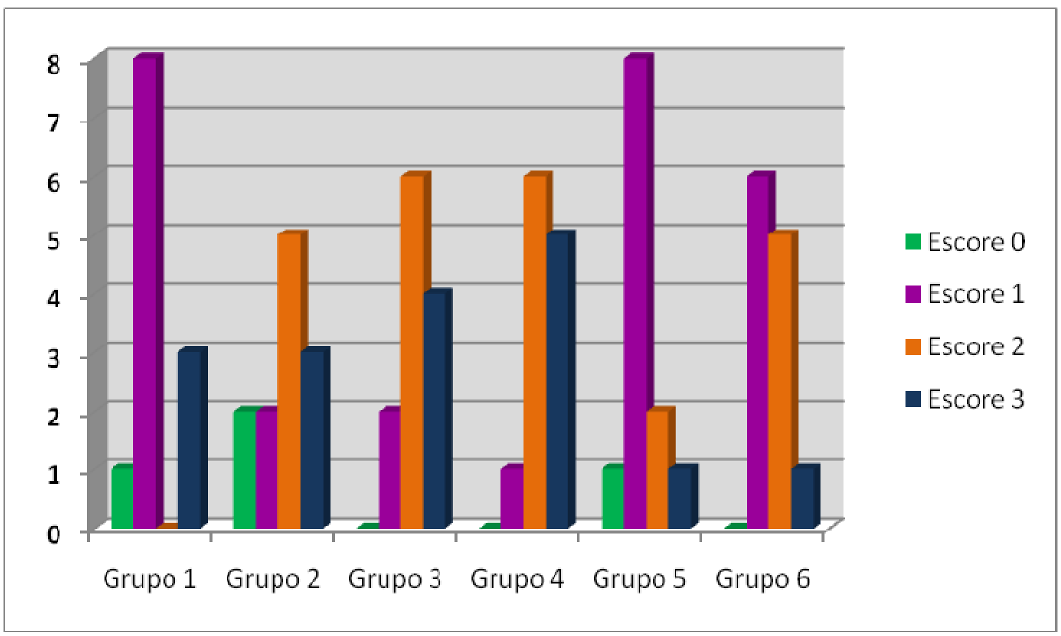

Figure 1: ARI scores

4 - Discussion

The Transbond XT composite was specifically developed for bonding orthodontic accessories to the enamel. The main advantages offered by this material are reduced working time, no manipulation, and adequate adhesion to enamel,[1,8] thus being largely used in clinical orthodontics and experimental essays as controls.[3,6,11] This composite was used in Group 1 as control and yielded a mean shear strength value of 24.6 MPa, which confirms its high adhesiveness to dental enamel.[8,10,12,25]

Transbond Plus Color Change (TPCC), which is characterised by its color change following photo-activation (pink to white), was the composite evaluated in this i*n vitro* study. Despite not being the objective of this study, it was observed that its pink color changed even when exposed to room light during the bonding procedures. This fact makes the color change to be a relative advantage as the orthodontist needs time to manipulate the material, place the accessory correctly, and remove the material excess, all clinical steps performed under room and even artificial light. The TPCC manufacturer provides this information on early color change in lightened environment and such a fact was observed in the present study.

Transbond XT and TPCC composites have some common components with very similar proportion[8] since the former has 14% BIS-GMA, 9% BIS-EMA, and 77% load particles and the latter has 12%, 8% and 80%, respectively. This difference in their compound proportions did not influence the shear strength values as no statistically significant differences were found between Groups 1 and 2, which used these composites conventionally.

In this study, brackets were bonded onto different enamel surfaces to known whether type of preparation interferes with the shear bond strength. In Group 3, TPSEP was applied to dry enamel before using TPCC for bonding the brackets. Since its launch in 2000, this self-etching agent has been tested in numberless bonding experiments, mostly yielding adhesive results similar to those from conventional systems.[3,6,10,14] In the present study, the combination between TPSEP and TPCC for dry enamel resulted in a mean shear strength value of 17.5 MPa. Although this value was statistically inferior to that of Group 1 (conventional Transbond XT), such a statistical difference was not observed when this same composite was used conventionally (Group 2). This shows that the etching pattern using either phosphoric acid or TPSEP did not interfere with the shear strength values.[6,10,14,19] Despite the different types of enamel surface preparations, no statistically significant differences were found between the groups (2 through 6) in which TPCC was used.

Using adhesive composites conventionally requires well-defined steps in order to assure adequate adhesion to enamel. Elimination of one of these steps without compromising the adhesiveness would facilitate the bonding procedure and prevent brackets from debonding. In Group 4, the TPCC composite was used with no previous application of XT primer despite the manufacturer’s instructions, yielding a shear strength value of 19.7 MPa. No statistically significant differences were found in Group 4 compared to Group 1 (control) and Group 2, which used the same composite conventionally. The other groups also showed no statistically significant differences. The results obtained in the present work are corroborated by other authors,[20,21,26] who found no statistically significant differences in shear strength values regardless of the use of bonding agent. On the other hand, some authors report that the bonding agents penetrate more deeply into the enamel, thus forming deeper and wider resin tags in addition to protecting the conditioned dental surface not occupied by the bracket base.[20,22,23]

Saliva contamination decreases the adherence of composites to enamel when they are applied conventionally,[5,7,24] resulting in many cases of bracket failures during the treatment. In order to reduce the number of bond failures involving loosen brackets, the manufacturers have been developing composites, self-etching primers, and hydrophilic primers that allow adhesion to occur even under saliva contamination or humidity. In Group 5, TPCC was used conventionally, but the enamel surface was contaminated by human saliva following application of XT primer. The value of 17.5 MPa was found to be statistically inferior to that of Group 1 (control) although no statistically significant differences were found between Group 5 and other groups using TPCC. This similarity between the values, including those regarding conventional bonding procedures, is possibly due to the hydrophilic characteristics of TPCC.

TPSEP is another hydrophilic material that was used in Groups 3 and 6 as etching agent, but in the latter group the brackets were bonded with TPCC after saliva contamination. The mean adhesive value for Group 6 (14.8 MPa) was the smallest one compared with all other groups, being statistically inferior to the control group, but no significant difference was observed in relation to other groups even when TPSEP was applied to dry enamel (Group 3). All these findings confirm that moisture can reduce the adhesiveness, but adhesion may be achieved by using hydrophilic materials.

All groups assessed (control and experimental) showed shear strength values superior to that reported by Reynolds[25] despite of some statistical differences, thus indicating that TPCC can be used for bracket bonding under different enamel conditions as tested here. Further clinical and laboratory studies need to be carried out to assess other characteristics of TPCC composite.

In laboratory experiments involving materials for bonding orthodontic accessories to enamel, both differences and similarities regarding shear strength values usually do not correspond to the ARI results.[4,10] This fact was also observed in the present study as statistical differences in the shear bond strength testing (Table 2) did not correspond to the ARI analysis (Table 3). It is important to evaluate the ARI scores following the debonding procedures in order to verify the amount of composite remnant on the enamel, that is, the more adhered the material is, the better (ARI = 3). In this way, one can be sure that no enamel fracture has occurred at all. ARI scores of all samples were assessed in order to quantify the remaining material: the majority of fractures occurred at the bracket/composite interface with some material left on enamel (ARI scores = 1, 2, and 3), whereas only four samples had no amount of composite adhered to enamel (ARI score = 0). These findings are commonly found in studies using composites as bonding material for orthodontic accessories.[4,14,16]

5 - Conclusion

The following conclusions can be drawn from the results above:

1 - TPCC achieved results comparable to those of conventional Transbond XT, with type of enamel preparation not influencing the shear strength values regarding this composite.

2 - When TPCC was used in enamel conditioned with TPSEP and contaminated by saliva, the adhesive results were inferior to those using Transbond XT.

3- In all the groups the majority of fractures involving the bracket/composite interface.

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CONSIDERAÇÕES GERAIS

Para realização de um adequado tratamento ortodôntico é necessário conhecimento científico e habilidade técnica diferenciada. É imprescindível também que o Ortodontista tenha informações dos materiais, de diferentes tipos e fabricantes que estão disponíveis para uso clínico. Especificamente para colagem direta de acessórios ortodônticos ao esmalte, existem diversos produtos, de distintas procedências, nacionais e importados. Alguns deles, previamente ao lançamento são testados pelo fabricante em experimentos laboratoriais, porém, a grande maioria, não são testados em estudos clínicos, ficando a cargo dos pesquisadores em centros de pesquisa ou universidades a responsabilidade de avaliá-los em condições reais, além de, verificar sua biocompatibilidade e estabilidade no meio bucal.

A qualidade da colagem clínica com os sistemas adesivos Concise Ortodôntico e Transbond XT, sendo este último utilizado em diferentes preparações de esmalte foi avaliada neste trabalho. A eficiência clínica dos sistemas testados foi de no mínimo 91% (Transbond XT sem agente de união), e atingiu 99% de sucesso com a associação do TPSEP + Transbond XT. O compósito Concise Ortodôntico obteve 92% de sucesso da colagem, sem diferença estatística significante em relação ao Transbond XT sem agente de união (92%). Apesar do alto desempenho dos sistemas adesivos do estudo clínico, quando foram comparados entre si, ficou evidente a superioridade adesiva do Transbond XT convencional e TPSEP + Transbond XT. Este resultado do compósito Transbond XT colado de acordo com as recomendações do fabricante confirma os achados da literatura tanto em experimentos *in vitro* quanto *in vivo.* A maioria das descolagens (90%) ocorreu nos primeiros 2 meses do período de observação, independente do sistema adesivo. Isto sugere que experimentos clínicos avaliando a taxa de descolagem de bráquetes possam ser realizados em menor período de tempo.

Embora não se conheça todas as propriedades e efeitos do agente autocondicionante TPSEP, este produto vem apresentando bons resultados nos diferentes tipos de estudo, surgindo como alternativa de condicionamento da superfície do esmalte em detrimento ao sistema convencional, ou seja, ataque ácido e aplicação do agente de união em passos separados. Porém, outros estudos necessitam serem realizados, investigando outras situações e também seus componentes, para efetivamente indicá-lo para uso no paciente.

Outra constatação deste primeiro capítulo foi que o material quimicamente ativado Concise Ortodôntico obteve desempenho inferior ao fotopolimerizável usado convencionalmente. Este produto é consagrado na literatura científica como adequado para colagem de acessórios ortodônticos ao esmalte, porém, como todo material quimicamente polimerizável, requer habilidade do profissional devido ao reduzido tempo de trabalho e necessita de tempo adicional para completa presa. Verificou-se que quando o Transbond XT foi utilizado contrariamente às recomendações do fabricante, ou seja, sem a aplicação do agente de união, obteve maior número de descolagem de bráquetes no período avaliado.

Cabe ressaltar que este modelo experimental desenvolvido no Capítulo 1, utilizando quatro materiais no mesmo paciente com variação do quadrante, tem originalidade científica, não tendo sido utilizado em nenhum outro experimento ao nosso alcance.

No segundo capítulo desta tese foi testado um compósito recentemente colocado á disposição do Ortodontista para uso. O TPCC (3M Unitek) apresenta mudança de cor após exposição à luz e possui propriedades hidrófilas. Possui alguns constituintes com proporções semelhantes ao Transbond XT, desta forma, deveria apresentar valores de adesão compatíveis. Esta expectativa foi confirmada, pois de maneira convencional não foram encontradas diferenças estatísticas significantes entre Transbond XT e TPCC.

Como relatado acima e confirmado em outros trabalhos científicos existe uma semelhança de resultados clínicos e laboratoriais entre Transbond XT convencional e TPSEP associado ao Transbond XT. Neste trabalho que avaliou este novo compósito (TPCC) posteriormente a aplicação do TPSEP foram encontrados valores adesivos menores numericamente, principalmente na presença de saliva, o que reforça que nesta situação ocorre queda do valor de adesão dos compósitos e que estes valores provavelmente não foram ainda menores devido às características hidrófilas, tanto do TPSEP quanto do TPCC. Apesar disto, os resultados obtidos nestas condições não foram estatisticamente diferentes entre os grupos de mesmo compósitos e também superiores aos índices propostos. A ausência de diferença estatística entre condicionamento convencional e preparo com ácido-primer (TPSEP) aconteceu nos dois capítulos deste trabalho, porém, com compósitos diferentes.

No capítulo 1 (estudo clínico) quando o Transbond XT foi utilizado sem agente de união ocorreram mais descolagens de bráquetes que os demais sistemas utilizados, sinalizando que a não execução deste passo poderá comprometer a adesão dos acessórios. Já no Capítulo 2 (estudo laboratorial), isto não ocorreu, pois quando o TPCC utilizou a mesma sistemática não houve diferença estatística significante em relação ao controle (Transbond XT convencional). Vale lembrar que os resultados de estudos *in vitro* não devem ser extrapolados indiscriminadamente para a clínica.

Em condições ideais, ou seja, *in vitro,* o novo compósito TPCC apresentou ausência de diferença estatística significante nas diversas preparações de esmalte, e valores até acima dos relatados como ideais por alguns autores. Porém, somente após o teste de colagem em condições reais, avaliação de biocompatibilidade e verificação da estabilidade de cor ao longo dos anos, este material pode ser indicado para uso rotineiro no paciente. Enquanto isto recomenda-se para colagem de acessórios ortodônticos diretamente ao esmalte dentário, o uso de compósitos já consagrados, com características conhecidas e aprovadas, como é o caso do Concise Ortodôntico e Transbond XT utilizados convencionalmente.

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APÊNDICE

1- Informações referentes ao Capítulo 1:

1.1 – Figuras dos materiais utilizados:

Figura 1: Sistema adesivo Concise Ortodôntico (3M do Brasil, Sumaré, Brasil)

Figura 2: Sistema adesivo Transbond XT convencional (3M Unitek, Monrovia, USA)

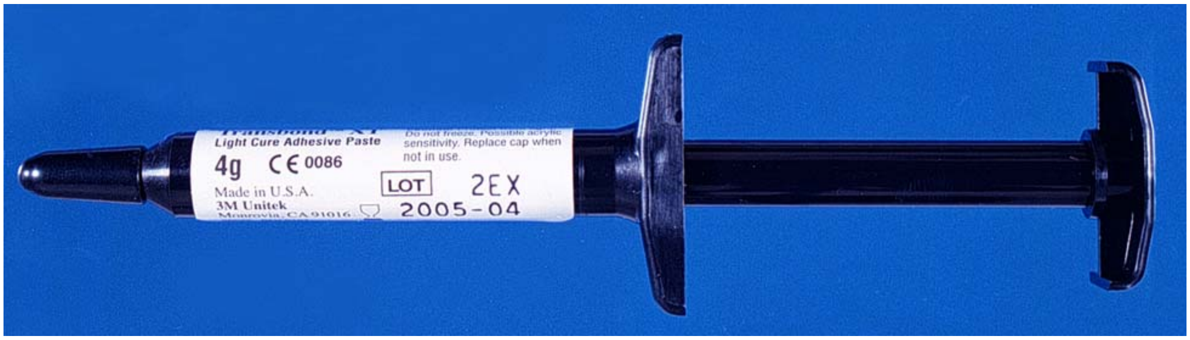

Figura 3: Sistema adesivo Transbond XT sem agente de união (3M Unitek, Monrovia, USA)

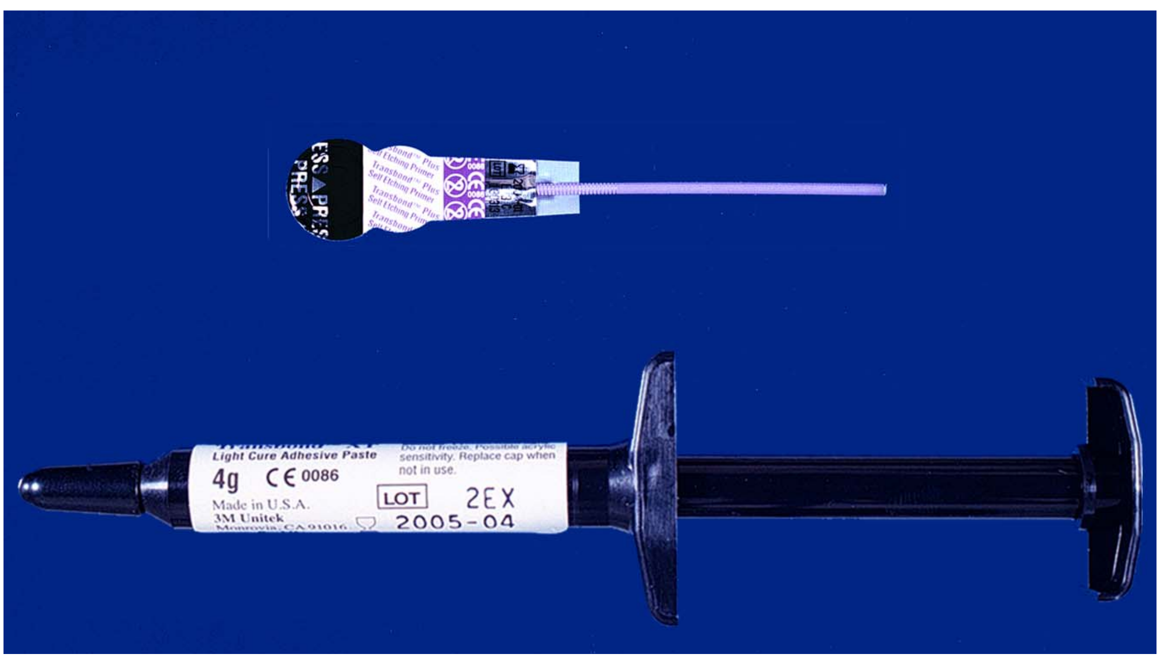

Figura 4: Sistema adesivo TPSEP + Transbond XT (3M Unitek, Monrovia, USA)

1.2 – Figuras dos passos clínicos da colagem com os sistemas adesivos utilizados:

Figura 5: Técnica de colagem com Concise Ortodôntico

A- Dente antes da colagem, **B-** Profilaxia com pedra-pomes e água por 10 segundos, **C-** Lavagem da profilaxia, **D-** Secagem, **E-** Condicionamento com ácido fosfórico a 37% por 15 segundos, **F-** Lavagem do condicionamento, **G-** Secagem, **H-** Aplicação da resina fluida, **I-** Aplicação de leve jato de ar, **J-** Compósito na base do bráquete, **K-** Posicionamento e remoção dos excessos, **L-** Acessório colado.

Figura 6: Técnica de colagem com Transbond XT convencional

A- Profilaxia com pedra-pomes e água por 10 segundos, **B-** Lavagem da profilaxia, **C-** Secagem, **D-** Condicionamento com ácido fosfórico a 37% por 15 segundos, **E-** Lavagem do condicionamento, **F-** Secagem, **G-** Aplicação do XT primer, **H-** Aplicação de leve jator de ar, **I-** Compósito na base do bráquete, **J-** Posicionamento e remoção dos excessos, **K-** Fotopolimerização por 40 segundos, **L-** Acessório colado.

Figura 7: Técnica de colagem com Transbond XT sem agente de união

A- Profilaxia com pedra-pomes e água por 10 segundos, **B-** Lavagem da profilaxia, **C-** Secagem, **D-** Condicionamento com ácido fosfórico a 37% por 15 segundos, **E-** Lavagem do condicionamento, **F-** Secagem, **G-** Compósito na base do bráquete, **H-** Posicionamento e remoção dos excessos, **I-** Fotopolimerização por 40 segundos, **J-** Acessório colado.

Figura 8a: Técnica de colagem com TPSEP + Transbond XT

A- Dente antes da colagem, **B-** Profilaxia com pedra-pomes e água por 10 segundos, **C-** Lavagem da profilaxia, **D-** Secagem, **E-** Aplicação do TPSEP esfregado por 3 segundos, **F-** Aplicação de leve jato de ar, **G-** Posicionamento do acessório, **H-** Remoção dos excessos, **I-** Fotopolimerização por 40 segundos, **J-** Acessório colado.

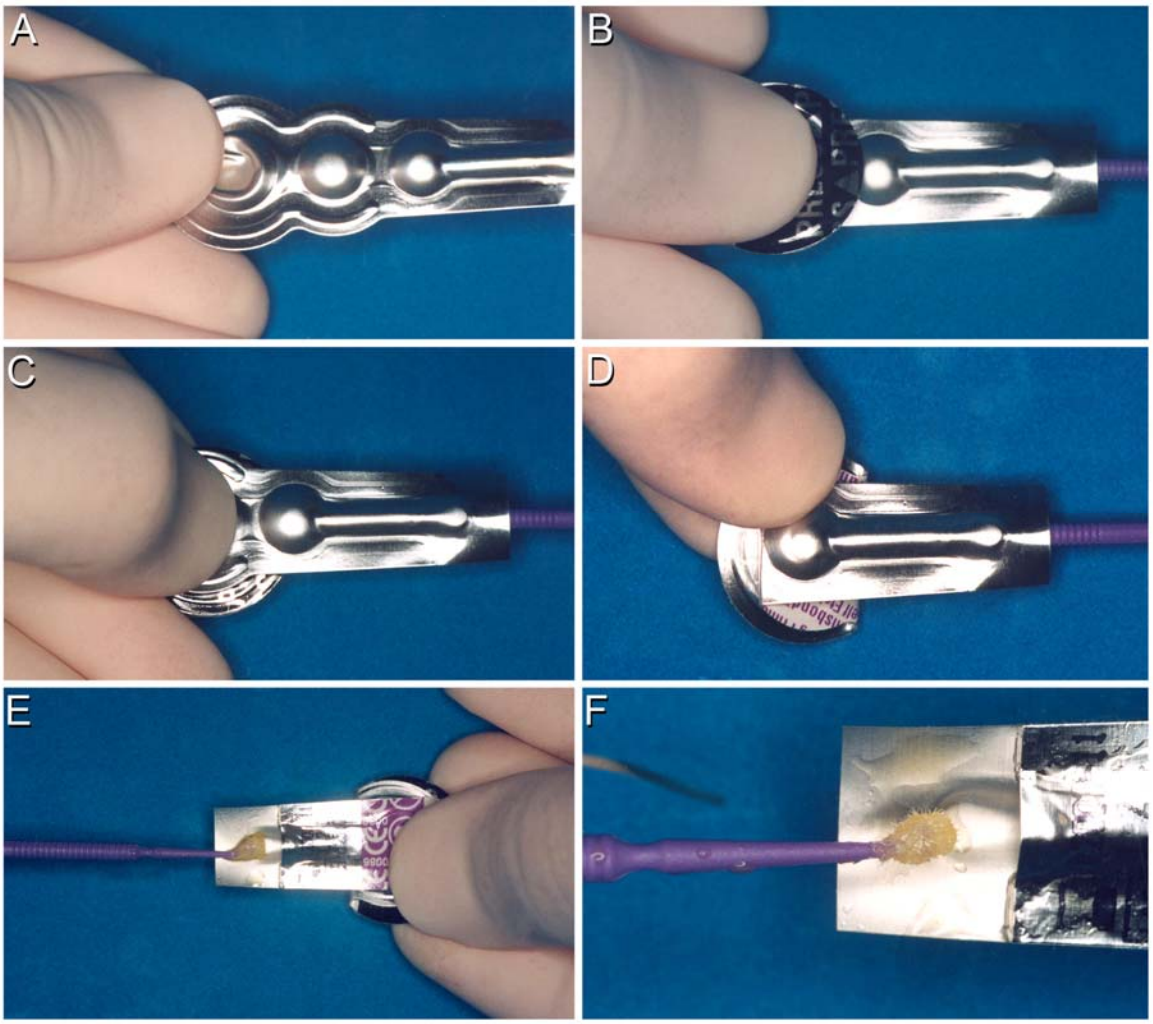

Figura 8b: Manipulação do TPSEP

1.3 – Ilustração gráfica dos resultados

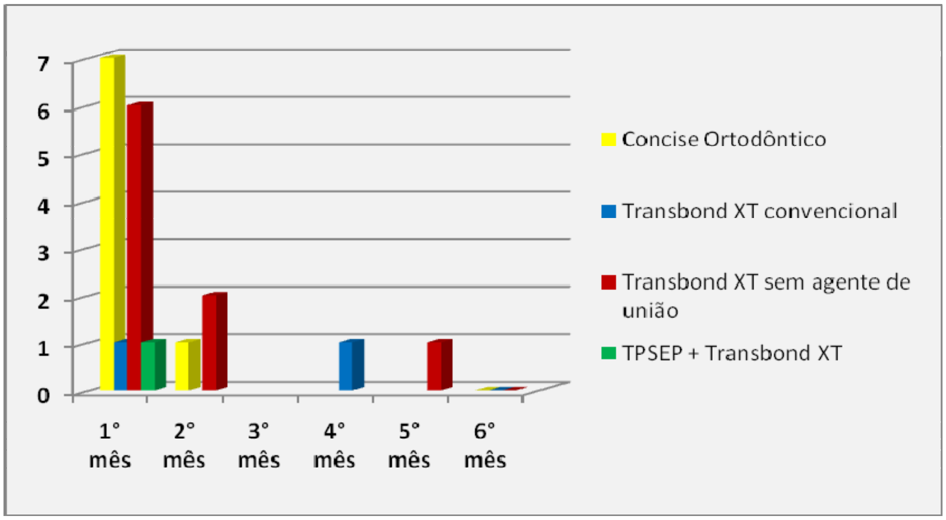

Figura 9: Número de bráquetes descolados/mês com cada sistema adesivo

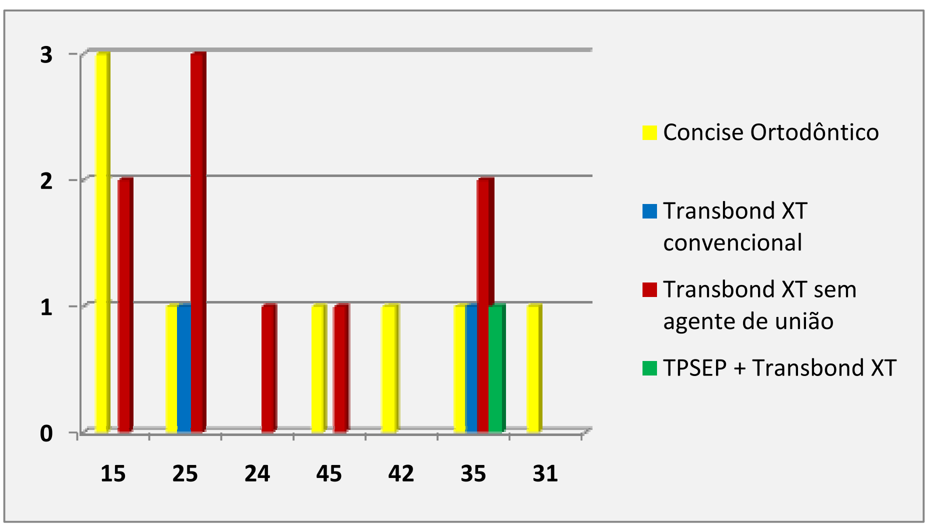

Figura 10: Dentes afetados pelas descolagens com cada material no arco superior e inferior

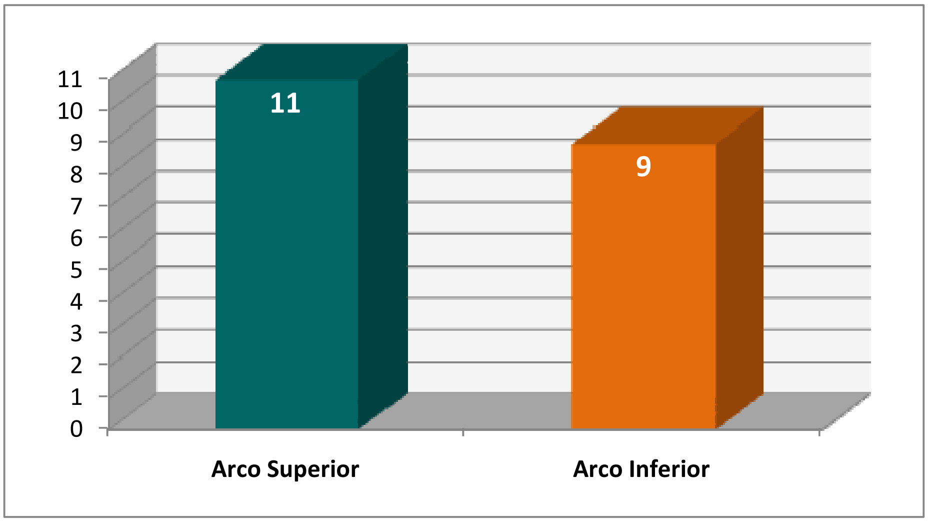

Figura 11: Comparação do número de descolagens entre os arcos dentários

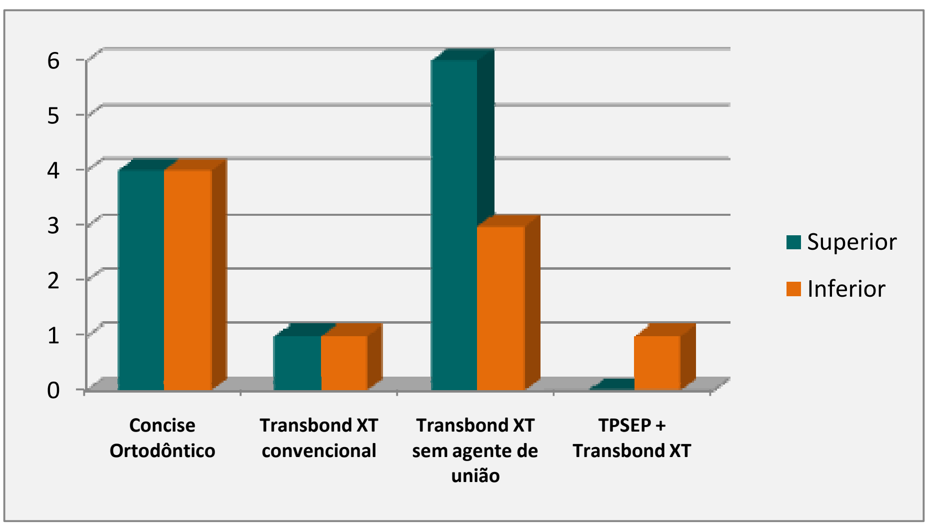

Figura 12: Comparação do número de descolagens entre os arcos dentários considerando cada sistema adesivo

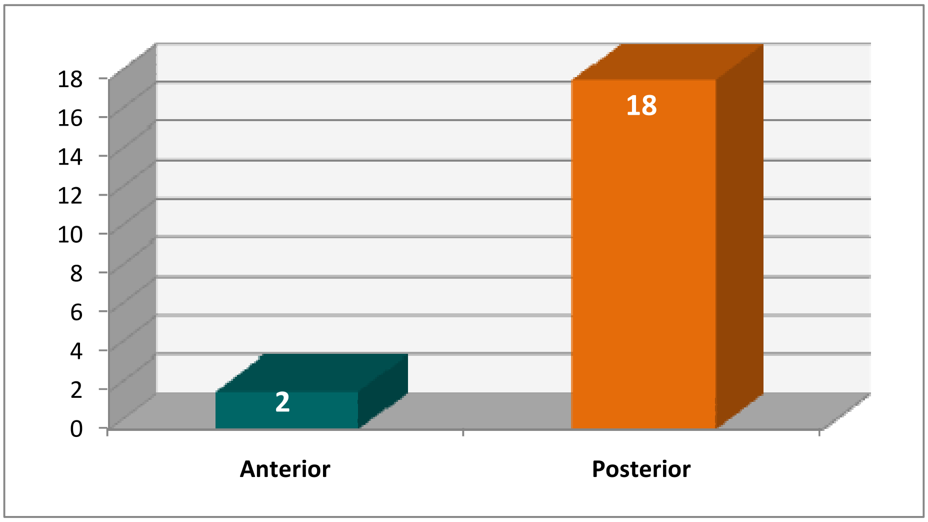

Figura 13: Comparação do número de descolagens entre as regiões dos arcos dentários

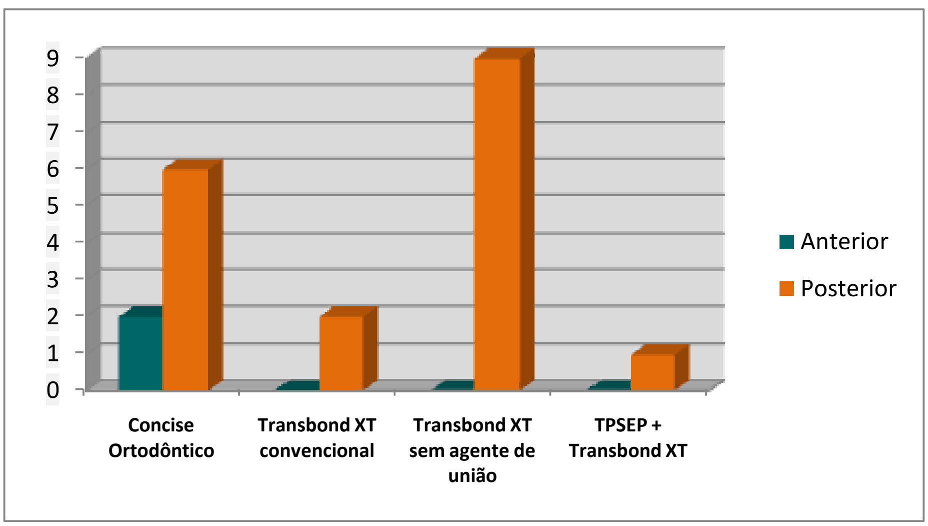

Figura 14: Comparação do número de descolagens entre as regiões dos arcos dentários considerando cada sistema adesivo

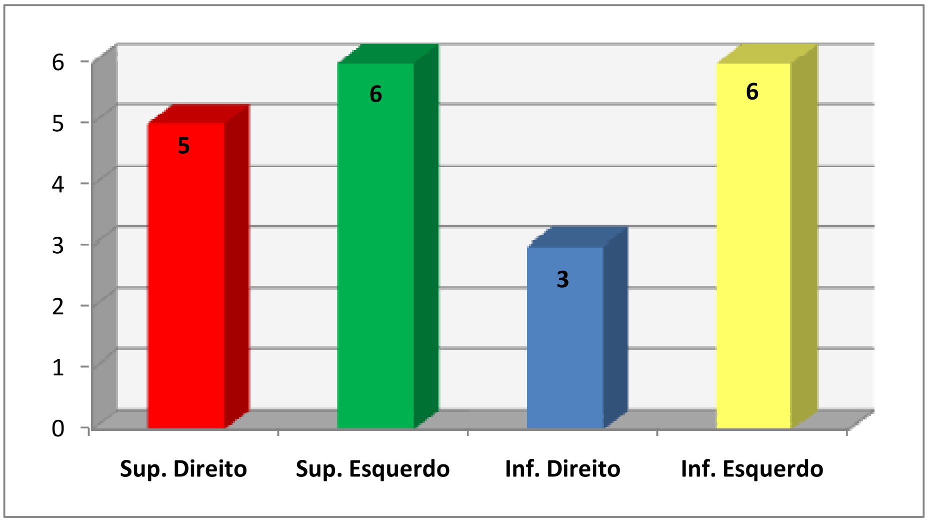

Figura 15: Comparação do número de descolagens entre os quadrantes dos arcos dentários

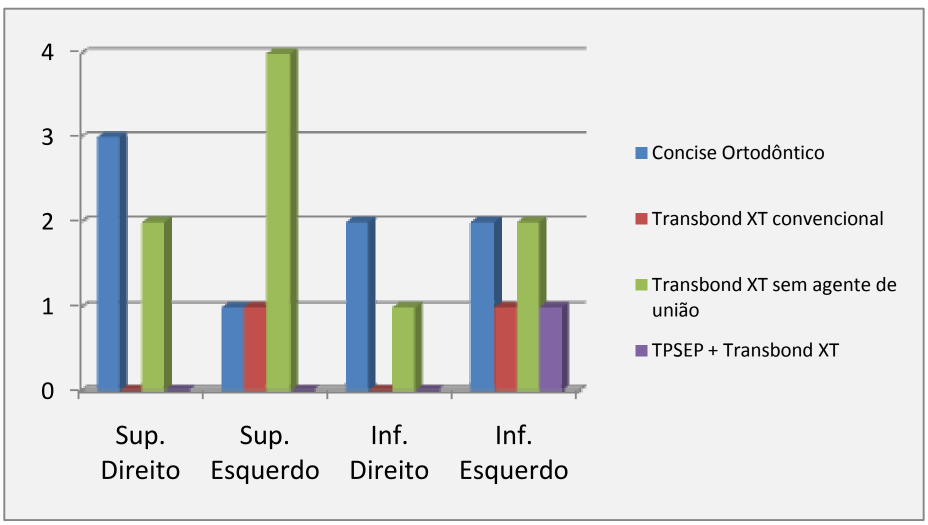

Figura 16: Comparação do número de descolagens entre os quadrantes dos arcos dentários considerando cada sistema adesivo

2 - Informações referentes ao Capítulo 2:

2.1 – Figura do material de colagem avaliado:

Figura 17: Compósito Transbond Plus Color Change (3M Unitek, Monrovia, USA)

2.2 – Figura da confecção do corpo-de-prova:

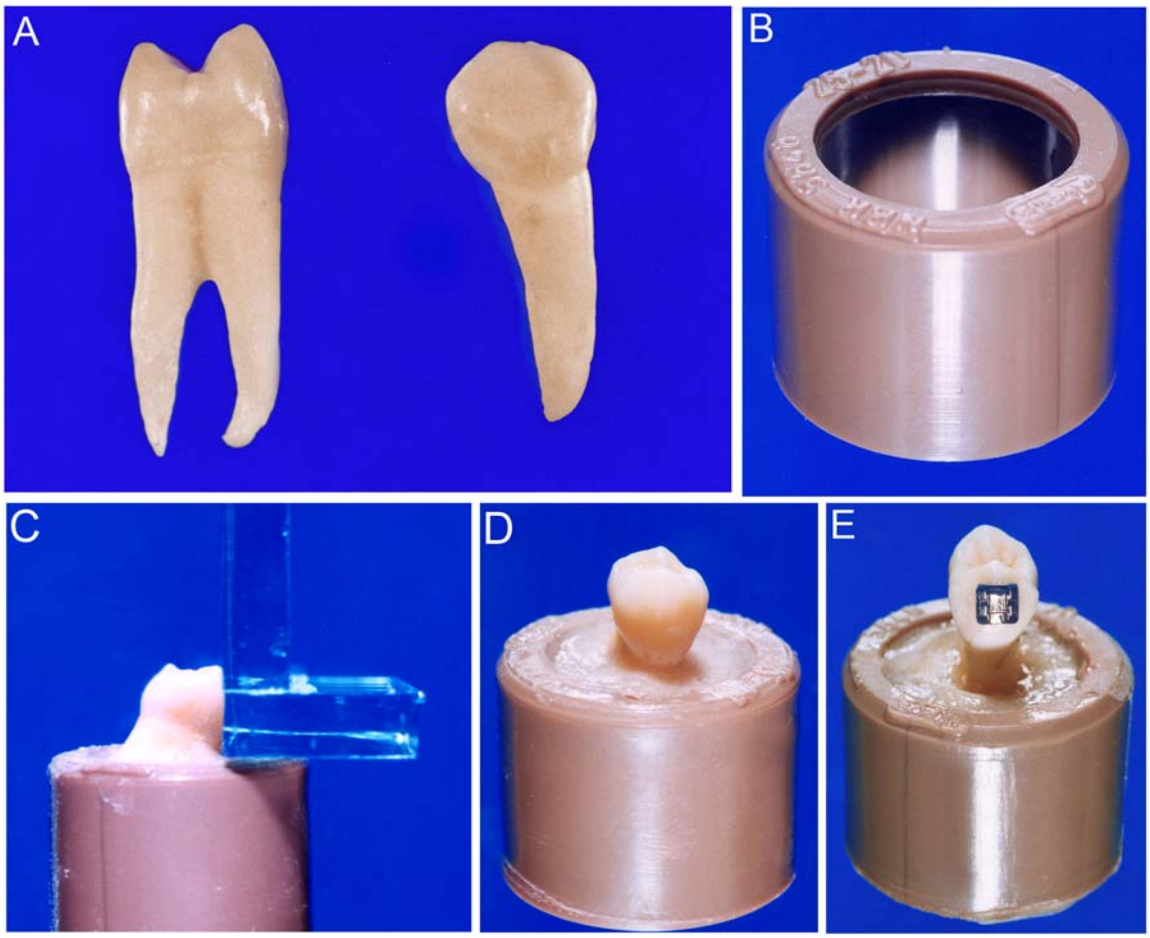

Figura 18: Passos da confecção do corpo-de-prova

2.3 – Figuras do ensaio de resistência ao cisalhamento

Figura 19: Máquina de ensaios mecânicos – Instron Corp. Modelo 44.11

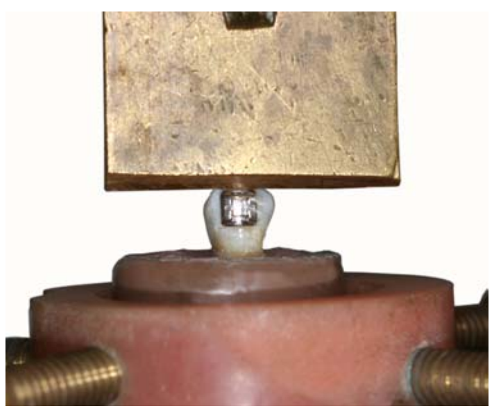

Figura 20: Ensaio de resistência ao cisalhamento com ponta ativa em cinzel apoiada na região da interface esmalte/compósito.

2.4 – Figura do Índice de Remanescente de Adesivo (IRA):

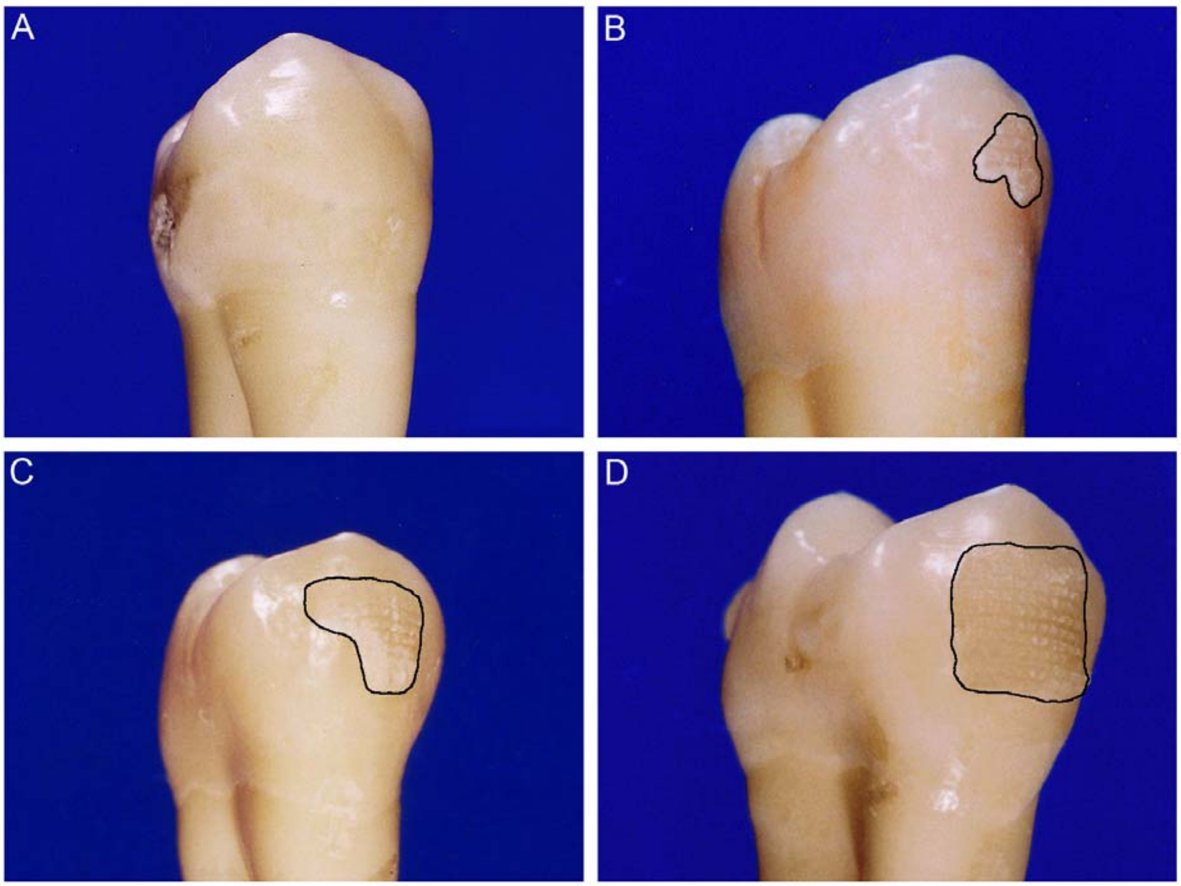

Figura 21: Variações do Índice de Remanescente de Adesivo (IRA)

A: 0 - Nenhum compósito remanescente

B: 1 - Menos da metade do compósito remanescente

C: 2 - Mais da metade do compósito remanescente

D: 3 - Todo compósito remanescente

2.5 - Ilustração dos resultados em tabelas:

Tabela 1: Análise de Variância (ANOVA) dos dados do Capítulo 2

Causas de Variação	GL	SQ	QM	F	P
Entre os grupos	5	7,049	1,410	4,472	0,002
Residual	54	17,024	0,315		
Total = 72	24,073				

Poder do teste α= 0,889

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Contact us:
brjorals@fop.unicamp.br

Editor-in-Chief: Prof Dr José Francisco Höfling
Piracicaba Dental School
University of Campinas
Av Limeira 901
13414-018 – Piracicaba – SP
Brasil
Phone: 55 19 2106 5706
Fax: 55 19 2106 5218
Web: www.fop.unicamp.br/brjorals
e-mail: brjorals@fop.unicamp.br

March 11, 2009

Dear Dr. Romano

Thank you for submitting your manuscript entitled **"Shear Bond Strength of Metallic Brackets Bonded with a New Orthodontic Composite"** to the Brazilian Journal of Oral Sciences. Please, refer to manuscript **#452** on all further correspondence.

In accordance with the new policy of the Brazilian Journal of Oral Sciences, the approved manuscripts will be submitted to a technical review concerning English language, **in order to fit them into the standards of the journal. The costs will be charged to the author(s). Submission of a manuscript to Brazilian Journal of Oral Sciences implies in the acceptance of these terms** (for more details, please see http://www.fop.unicamp.br/brjorals). Moreover, **Brazilian Journal of Oral Sciences** reserves the right to edit manuscripts to ensure conciseness, clarity, and stylistic consistency and to fit articles to available space. Please, send us an e-mail (brjorals@fop.unicamp.br) about your agreement with these statements, in order to start the review process.
We will contact you again as soon as we have the necessary information for an editorial decision.

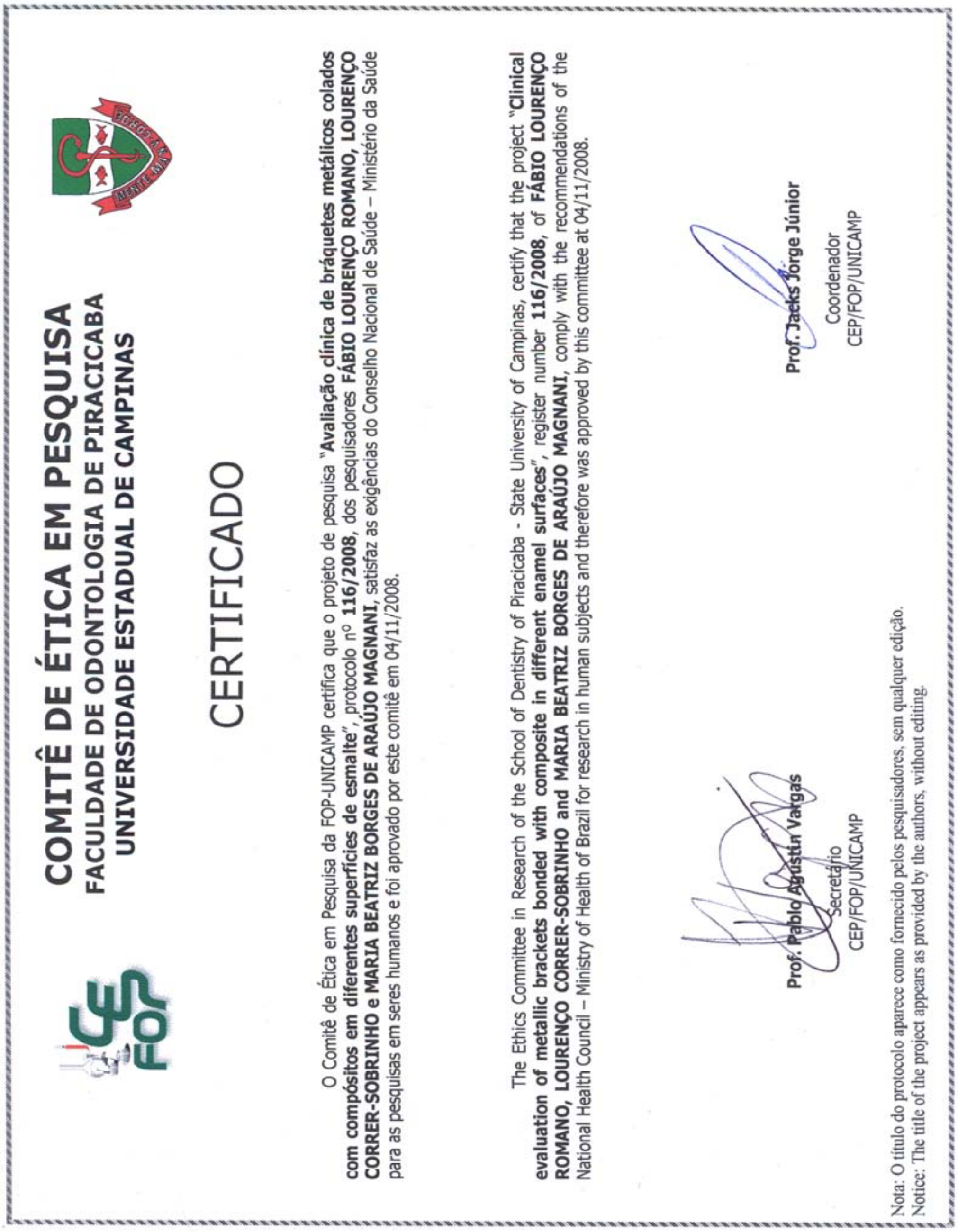
Sincerely yours,

JF Höfling
Scientific Editor
Brazilian Journal of Oral Sciences

ANEXO

1- Certificados do Comitê de Ética em Pesquisa em humanos

Capítulo 1:



COMITÊ DE ÉTICA EM PESQUISA
FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa "**Avaliação clínica de bráquetes metálicos colados com compósitos em diferentes superfícies de esmalte**", protocolo nº **116/2008**, dos pesquisadores **FÁBIO LOURENÇO ROMANO, LOURENÇO CORRER-SOBRINHO e MARIA BEATRIZ BORGES DE ARAÚJO MAGNANI**, satisfaz as exigências do Conselho Nacional de Saúde – Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 04/11/2008.

The Ethics Committee in Research of the School of Dentistry of Piracicaba - State University of Campinas, certify that the project "**Clinical evaluation of metallic brackets bonded with composite in different enamel surfaces**", register number **116/2008**, of **FÁBIO LOURENÇO ROMANO, LOURENÇO CORRER-SOBRINHO and MARIA BEATRIZ BORGES DE ARAÚJO MAGNANI**, comply with the recommendations of the National Health Council – Ministry of Health of Brazil for research in human subjects and therefore was approved by this committee at 04/11/2008.

Prof. Pablo Agustín Vargas
Secretário
CEP/FOP/UNICAMP

Prof. Jacks Jorge Júnior
Coordenador
CEP/FOP/UNICAMP

Nota: O título do protocolo aparece como fornecido pelos pesquisadores, sem qualquer edição.
Notice: The title of the project appears as provided by the authors, without editing.

Capítulo 2:

COMITÊ DE ÉTICA EM PESQUISA
FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa "**Avaliação laboratorial de bráquetes metálicos colados com compósitos em diferentes superfícies de esmalte**", protocolo nº **128/2008**, dos pesquisadores **FÁBIO LOURENÇO ROMANO, LOURENÇO CORRER-SOBRINHO e MARIA BEATRIZ BORGES DE ARAÚJO MAGNANI**, satisfaz as exigências do Conselho Nacional de Saúde – Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 05/11/2008.

The Ethics Committee in Research of the School of Dentistry of Piracicaba - State University of Campinas, certify that the project "**Laboratory evaluation of metallic brackets bonded with composite in different enamel surfaces**", register number **128/2008**, of **FÁBIO LOURENÇO ROMANO, LOURENÇO CORRER-SOBRINHO and MARIA BEATRIZ BORGES DE ARAÚJO MAGNANI**, comply with the recommendations of the National Health Council – Ministry of Health of Brazil for research in human subjects and therefore was approved by this committee at 05/11/2008.

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Universidade Estadual de Campinas
Faculdade de Odontologia de Piracicaba

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Piracicaba, 23 de abril de 2009.

____
Fábio Lourenço Romano
RG: 5043585 SSP/MG
Autor

____
Profa. Dra. Maria Beatriz Borges de Araújo Magnani
RG:7798577 SSP/SP
Orientadora

____
Prof. Dr. Lourenço Correr Sobrinho
RG: 13653310 SSP/SP
Co-Orientador