

Assessment of variability in experiments in the operative dentistry area applied to shear bond strength tests

**Bruna Maria Covre Garcia da SILVA^a, Gláucia Maria Bovi AMBROSANO^b,
Flávia Martão FLÓRIO^c, Roberta Tarkany BASTING^d**

^a*Departamento de Materiais Dentários, Centro de Pesquisas Odontológicas,
São Leopoldo Mandic, 13045-755 Campinas - SP, Brasil*

^b*Departamento de Bioestatística, Faculdade de Odontologia de Piracicaba,
Universidade Estadual de Campinas – UNICAMP, 13414-903 Piracicaba - SP, Brasil*

^c*Departamento de Odontologia Preventiva, Centro de Pesquisas Odontológicas,
São Leopoldo Mandic, 13045-755 Campinas - SP, Brasil*

^d*Departamento de Dentística, Centro de Pesquisas Odontológicas, São Leopoldo Mandic,
13045-755 Campinas - SP, Brasil*

Silva BMCG, Ambrosano GMB, Flório FM, Basting RT. Avaliação da variabilidade em experimentos na área de dentística aplicada a testes de resistência ao cisalhamento. Rev Odontol UNESP. 2009; 38(2): 117-21.

Abstract: The aim of this work was to assess the coefficient of variation (CV) distribution in experiments in the Dentistry area, involving shear strength tests using human teeth, published in various periodicals, as well as in the Medline-Pubmed data base. Material and method: A bibliographic survey was made in national and international periodicals published between 1998 and 2004, as well as in those in the Medline-Pubmed (1991 to 2005) data base. Result: The data found (central tendency and dispersion measurements) were tabled and their normality was tested using the program SAS - Statistical Analysis System (Shapiro-Wilk, $\alpha = 0.05$). As the data did not present normal distribution, limits of the classification ranges were proposed, and the quartiles were used. The CV median of the studies involving shear strength tests was equal to 25.88. Conclusion: Data analysis allowed one to define that for the studied variable, the coefficient of variation values are considered low when $CV \leq 18.46$; medium when $18.46 < CV * 25.88$; high when $25.88 < CV * 34.00$ and very high when $CV > 34.00$.

Keywords: *Statistical analysis; Dentistry; shear strength.*

Resumo: Objetivo: Avaliar a distribuição do coeficiente de variação (CV) em experimentos na área de Dentística envolvendo testes de resistência ao cisalhamento utilizando dentes humanos, publicados em vários periódicos, assim como na base de dados Medline-Pubmed. Material e método: Foi realizado um levantamento bibliográfico em que se determinou o valor médio de CV da variável estudada, tanto em periódicos nacionais e internacionais publicados entre 1998 e 2004, como também naqueles presentes na base de dados Medline-Pubmed (1991 a 2005). Resultado: Os dados encontrados foram tabulados e sua normalidade foi testada utilizando o programa SAS - Statistical Analysis System (Shapiro-Wilk, $\alpha = 0,05$). Posteriormente, foram propostos os limites das faixas de classificação, utilizando-se a relação entre média e desvio padrão dos valores de CV. A média do CV de estudos envolvendo testes de resistência ao cisalhamento foi igual a 25,88. Conclusão: A análise dos dados permitiu definir que, para a variável estudada, os valores de coeficiente de variação são considerados baixos quando $CV \leq 18,46$; médios quando $18,46 < CV * 25,88$; altos quando $25,88 < CV * 34,00$ e muito altos quando $CV > 34,00$.

Palavras-chave: *Análise estatística; Odontologia; resistência ao cisalhamento.*

Introduction

The coefficient of variation (CV), defined as the standard deviation in percentage of the mean, is the statistical measurement most used by researchers to assess the precision of experiments, without the need for equality of units¹. In spite of all the concern about quality, articles have still been published with indications of low experimental precision, frequently because of lack of suitable reference values for comparison. Generally speaking, in experimentation tests with low precision, this could lead to researchers obtaining incorrect conclusions from the results, thus increasing the probability of errors.

The CV is an important measurement to describe the variability of experimental results, and may be useful for defining the number of repetitions of the test necessary to detect a difference between means of treatment, with a given probability². It is represented by the standard deviation, expressed as a percentage of the mean and calculated by the following expression:

$$CV = \frac{s}{x} \times 100 \quad (1)$$

where s is the square root of residual variance and is the general mean of the experiment^{3,4}.

It is emphasized that it is of great importance to know the reasonable values of this measurement in the different areas of knowledge, as these vary in accordance with the studied treatment and with the variable-response used⁴⁻⁵. It is known that determining the distribution of CV enables ranges of values to be established, which guide the researcher as regards the validity of his/her experiments⁶, and it is necessary to know when a CV value is considered low, medium, high or very high, to allow the size of samples to be determined and the populational mean to be estimated⁷. On the basis of agricultural tests performed in the field, CV results below 10% may be considered low, medium when they vary from 10 to 20%, high from 20 to 30% and very high when they exceed 30%³. In dental material researches, there are several publications with adequate statistical analyses. Braga et al.⁸ (1999), Cardoso et al.⁹ (1998), Nakaoki et al.¹⁰ (2002), Rikzalla, Jones¹¹ (2004), Sano et al.¹² (1998) and Wolf et al.¹³ (1992), however, appear to understand the importance of CV in precision researches and present it in their analyses. The same occurs with researches involving shear strength tests, bearing in mind that the dental substrate – to which the treatments are applied to assess the bond strength of materials or systems to dentin or enamel – may present variations due to the different degrees of mineralization, organic contents and dental age, among others. Variations may also occur due to test specimen handling, manipulation of the materials and the bond area which, being larger than the bond area of test specimens in microtensile tests, may lead to variations in the results of the bond strength tests¹².

The aim of this work was to assess the coefficient of variation (CV) distribution in experiments in the Dentistry area, involving shear strength tests using human teeth, published in various periodicals, as well as in the Medline-Pubmed data base.

Material and method

Data for doing this work was obtained through a survey of various periodicals and the Medline-Pubmed data base, and search of articles about work done on shear strength tests in human teeth. Experiments that presented both an estimate of CV and/or the presence of data that would allow it to be obtained (mean, standard deviation, mean standard error and number of repetitions) were selected. The use of these statistical tests, as well as those that were more frequently used was also observed.

A total of CV 223 of experiments were obtained in 16 different national and internationally indexed periodicals, from the year 1991 to 2005 (Table 1). The normality of the CV was tested by analysis using the Shapiro-Wilk test¹⁴ in the program SAS (Statistical Analysis System).

The quartiles were calculated, Q1 (inferior quartile) being the value below which a quarter of the data are found (lowest values), Q2 (median) the value that limits 50% of the data and Q3 (superior quartile) the value below which three quarters of the data are found. These measurements are obtained, ordering the data from the lowest to the highest and dividing them into four parts, being very useful in cases of data with non-symmetrical distribution.

Result

All the articles consulted in the periodicals presented results that used statistical analysis. The majority of them (73.8%) presented dispersion values, especially standard deviation. Nevertheless, the coefficient of variation was mentioned in only 1 article (1.6%) (Table 2).

Assessment of the statistical tests used in shear strength studies showed that the Analysis of Variance was the most frequently used test (ANOVA; 63.9%), followed by the Student's t -test (29.5%) and the multiple comparison tests (Tukey and Student Newman Keuls tests) (Table 3).

The data normality assessment (H_0 = normal distribution) by the Shapiro Wilk test demonstrated that the coefficient of variation did not present normal distribution ($p < 0.0001$). The median of the CV was equal to 25.88, the inferior quartile 18.46 and the superior 34.00. Data analysis allowed one to attribute grades to the coefficient of variation values for the studied variable, as can be seen in Table 4.

Discussion

The Medline-Pubmed database is one of the bibliographic research tools most used in the health area, allowing

Table 1. Periodicals consulted and number of articles found with the studied variable being analyzed

Periodicals	Articles	%
American Journal of Dentistry	21	34.4
Journal of Adhesive Dentistry	15	24.6
Quintessence International	5	8.2
American Journal of Orthodontics and Dentofacial Orthopedics	3	4.9
Dental Materials	3	4.9
Angle Orthodontists	2	3.3
Journal of Clinical Pediatric Dentistry	2	3.3
Operative Dentistry	2	3.3
Brazilian Oral Research	1	1.6
Brazilian Dental Science	1	1.6
European Journal of Oral Science	1	1.6
International Journal of Paediatr Dentistry	1	1.6
Journal of American Dental Association	1	1.6
Journal of Esthetic and Restorative Dentistry	1	1.6
Pediatric Dentistry	1	1.6
Pesquisa Odontológica Brasileira	1	1.6
Overall total	61	100.0

Table 2. Frequency of studies presenting statistical analysis, dispersion parameters and coefficient of variation

	Shear bond strength test	
	N	%
Statistical analysis	61	100
Dispersion parameters	45	73.8
Coefficient of variation	1	1.6

Table 3. Frequency of statistical tests used in the studies assessed

Statistical Test	Shear bond strength test	
	N	%
ANOVA	39	63.9
<i>t</i> -Test	18	29.5
Tukey	14	23.0
Student-Newman-Keuls	9	14.8
Duncan	4	6.6
Fischer's exact	2	3.3
Sidak	2	3.3
Dunnett	1	1.6
Scheffé	1	1.6
Wilcoxon-Mann-Whitney	1	1.6
Kruskal-Wallis	–	–
Others	3	4.9

important information to be found for research and practice. The MEDLINE database covers over 4800 journals published in the United States and in over 70 other countries from 1966 up to the present, and for this reason, has become indispensable for the development of biological sciences¹⁵, especially Dentistry.

With the development of new adhesive systems that present greater bond strength, shear strength and tensile tests have shown high incidence of cohesive fractures in dentinal substrate during the tests¹⁶. This fact can be associated with a non-uniform stress distribution at the adhesive interface¹⁷. Due to the larger adhesion area, bubbles may occur in the bond area, and the test may allow a non-homogeneous dissipation of stress in the specimen during test specimen "breakage". To minimize this inconvenience¹⁸, the microtensile test was introduced in Dentistry, which seems to demonstrate a better stress distribution, and a lower number of defects at the interface, thus minimizing the incidence of cohesive fractures when compared with conventional shear tests. Furthermore, the variability associated with the microtensile test diminished to 10-25%, instead of 30-50% commonly found in conventional tests, guaranteeing greater precision in the results¹⁹. Shear strength tests are, however, still frequently used, due to the ease of preparing and obtaining specimens, and also because it is presented as a recognized method in the literature.

Table 4. Distribution of the coefficient of variation values for the variable shear bond strength using human teeth

	Coefficient of variation (%)			
	Low	Medium	High	Very High
Shear bond strength test	≤ 18.46	$18.46 < CV \leq 25.88$	$25.88 < CV \leq 34.00$	> 34.00

The use of adhesive restorative materials has allowed conservative techniques to be applied for restoring dental surfaces²⁰. Therefore, the study of new adhesive materials by means of laboratory tests has been of great importance for their development and improvement. Among the tests available for analysis, shear tests are widely used with the main objective of determining the strength of the bond interfaces, adherence capacity, resistance to cutting, as well as to quantify the performance of the materials under torsion²¹. Adhesive systems were developed to allow sealing between the restoration and the dental substrate²². However, should the bond fail, there is the possibility that microleakage will occur (passage of bacteria, fluids, chemical substances, molecules and ions between the tooth and restoration), which could harm the longevity of the restoration, contributing to the appearance of staining, recurrent caries and adverse pulp response, in addition to post-operative sensitivity²³.

Thus, it is necessary determine the number of samples necessary for experiments in the area, as well as the type that use shear strength tests. The aim is to work with the lowest possible coefficient of variation, since the lower the CV, the greater will be the data homogeneity, and the lower the random variation²⁴. Some authors have emphasized the importance of the CV in planning experiments, determining sample sizes and estimating the populational mean⁷.

Conclusion

The results obtained in a research involving shear strength tests can be reliable, however, it is necessary to regularize the CVs presented in these articles, in order to reduce the chances of errors, and allow researchers to determine their results with precision.

References

1. Amaral AM do, Muniz JA, Souza M de. Avaliação do coeficiente de variação como medida da precisão na experimentação com citros. *Pesquisa Agropecuária Brasileira*. 1997;32:1221-5.
2. Mead R, Curnow RN. *Statistical methods in agriculture and experimental biology*. New York: Chapman and Hall; 1986.
3. Pimentel Gomes F. *Curso de estatística experimental*. 12th ed. São Paulo: Nobel; 1976.
4. Judice MG, Muniz JA, Carvalheiro R. Avaliação do coeficiente de variação na experimentação com suínos. *Ciência e Agrotecnologia*. 1999; 23:170-3.
5. Steel RGD, Torrie JH. *Principles and procedures of statistics: with reference to the biological sciences*. New York: McGraw-Hill; 1980.
6. Snedecor GW, Cochran WG. *Statistical methods*. 7th ed. Ames: The Iowa State University Press; 1980.
7. Gupta S, Singh KS. Estimation of population mean using coefficient of variation and auxiliary information. *Brazilian Journal of Probability and Statistics*. 1998;12:35-40.
8. Braga RR, Ballester RY, Carrilho MR. Pilot study on the early shear strength of porcelain-dentin bonding using dual-cure cements. *J Prosthet Dent*. 1999;81:285-9.
9. Cardoso PEC, Braga RR, Carrilho MR. Evaluation of micro-tensile, shear and tensile tests determining the bond strength of three adhesive systems. *Dent Mater*. 1998;14:394-8.
10. Nakaoki Y, Nikaido T, Burrow MF, Tagami J. Effect of residual water on dentin bond strength and hybridization of a one-bottle adhesive system. *Oper Dent*. 2002;27:563-8.
11. Rizkalla AS, Jones DW. Indentation fracture toughness and dynamic elastic moduli for commercial feldspathic dental porcelain materials. *Dent Mater*. 2004;20:198-206.
12. Sano H, Kanemura N, Burrow MF, Inai N, Yamada T, Tagami J. Effect of operator variability on dentin adhesion: students vs. dentists. *Dent Mater*. 1998;17:51-8.
13. Wolf DM, Powers JM, O'Keefe KL. Bond strength of composite to porcelain treated with new porcelain repair agents. *Dent Mater*. 1992;8:158-61.
14. Shapiro SS, Wilk MB. An analysis of variance test for normality (complete samples). *Biometrika*. 1965;52:591-611.
15. Curso sobre acesso às bibliotecas on-line da Medline/ Pubmed. HPS CANOAS; 2008. p. 1-13.
16. Pashley DH, Sano H, Ciucchi B, Yoshiyama M, Carvalho RM. Adhesion testing of dentin bonding agents: a review. *Dent Mater*. 1995;11:117-25.
17. Van Noort R, Noroozi S, Howard IC, Cardew GE. A critique of bond strength measurements. *J Dent*. 1989; 17:61-7.
18. Sano H, Shono T, Sonoda H, Takatsu T, Ciucchi B, Carvalho R, et al. Relationship between surface area for adhesion and tensile bond strength - evaluation of a micro-tensile bond test. *Dent Mater*. 1994;10:236-40.
19. Pashley DH, Carvalho RM, Sano H, Nakajima M, Yoshiyama M, Shono Y, et al. The microtensile bond test: a review. *J Adhes Dent*. 1999;1:299-309.

20. Mjör IA, Toffenetti F. Secondary caries: a literature review. *Quintessence Int.* 2000;31:165-79.
21. Elias NC, Lopes HL. *Materiais dentários – ensaios mecânicos.* São Paulo: Livraria Editora Santos; 2007.
22. Cal E, Türkün LS, Türkün M, Toman M, Toksavul S. Effect of an antibacterial adhesive on the strength of three different luting resin composites. *J Dent.* 2006;34:372-80.
23. Bergenholtz G, Cox CF, Loesche WJ, Syed SA. Bacterial leakage around dental restorations: its effect on the dental pulp. *J Oral Pathol Med.* 1982;11:439-50.
24. Judice MG, Muniz JA, Aquino LH de, Bearzoti E. Avaliação da precisão experimental em ensaios com bovinos de corte. *Ciência e Agrotecnologia.* 2002;26: 1035-40.

Autor para correspondência:

*Profa. Dra. Roberta Tarkany Basting
rbasting@yahoo.com*

Recebido: 13/11/2008

Aceito: 27/04/2009

