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Dimensional Changes in Gypsum Fragments Bonded with Cyanoacrylate

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Keywords
Gypsum; fracture; cyanoacrylate adhesive.

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Accepted October 7, 2010

doi: 10.1111/j.1532-849X.2011.00729.x

Abstract

Purpose: Accidental fractures may occur during manipulation and transportation of plaster casts. In clinical practice, plaster fragments may be bonded without harming the accuracy of the final denture, provided that the bonding agent does not cause dimensional alterations. Cyanoacrylate could be a good material because of its ease of use, quick set, wide availability, and low cost. The aim of this study was to assess the dimensional alteration of Type IV plaster fragments bonded with a cyanoacrylate-based adhesive.

Materials and Methods: Ten hexagonal regular prisms were made of Type IV plaster, with two reference marks on one of the faces. The distance between the marks was measured under a comparison microscope. After this, the prisms were fractured so that the fracture line would be between the two reference marks, bonded with a cyanoacrylate-based universal adhesive and measured again.

Results: The mean difference between the measurements performed before and after fracture and bonding of the fragments was 0.0194 mm. At a level of significance of 0.05, there was no statistically significant difference between the measurements before and after fracture and bonding of the dies ($p = 0.1582$).

Conclusion: It may be concluded that bonding of Type IV plaster fragments with a cyanoacrylate-based adhesive did not cause significant dimensional alterations.

During the fabrication of dental prostheses, the most commonly used material for making dies is Type IV plaster, because it has the following properties: (1) it is easy to use; (2) it is compatible with the majority of impression materials; (3) has dimensional stability; (4) reproduces details; and (5) has acceptable setting expansion and good resistance to compression.[1-4] However, some characteristics of plaster dies are not beneficial, such as surface hardness and susceptibility to abrasion and fracture.[5,6] Schwedhelm and Lepe[5] mention the risk of fractures when removing a cast from the impression, especially if there are long and narrow tooth preparations and if the impression material is rigid. In these cases, the authors recommend that the casts should only be removed from the impressions 12 to 24 hours after they are poured.

Accidental fractures may also occur during manipulation and transportation of the plaster casts. Springmann and Vieira[7] and Hanson et al[8] assessed the effects of bonding plaster fragments and suggested that this procedure may be performed in clinical practice without affecting the accuracy of the final denture. Likeman and Paolinelis[9] investigated the error in repairing fractured teeth in stone casts using a contact scanner and found a mean angular displacement of 0.72°. Among the various materials tested in these studies, cyanoacrylate has performed better than the other tested materials.

Cyanoacrylate is a universal adhesive known as "instant glue." It has been used in surgery instead of sutures and helps decrease postoperative bleeding.[10,11] It is considered to have good biocompatibility.[12] In dentistry, cyanoacrylate has been used for suturing, fixation of gingival grafts,[13] autogenous bone grafts,[14] closing of maxillary sinus membrane perforations,[15] nerve reanastomosis,[16] as retrofilling material in endodontic surgeries,[17] and as a cervical plug for pulpless tooth bleaching.[12] It can also be used to bond orthodontic brackets to enamel[18] and to bond orthodontic wires for dental splints.[19,20]

In prosthodontics, cyanoacrylate adhesive has been used for improving the properties of plaster dies. The application of a layer of cyanoacrylate over the plaster increases surface hardness[21,22] and resistance to abrasion,[21-24] diminishes water sorption,[23] and helps preserve the preparation margin on stone die.[21,23] Furthermore, cyanoacrylate is simple to use, sets quickly, is easily found, and is relatively inexpensive.

The success of the plaster fragment-bonding procedure depends on the exact repositioning of the parts and the bonding material's capacity to form a film of clinically negligible thickness, in order not to cause significant dimensional alteration of the set. Fukui et al[22] and Ghahremannezhad et al[21] found a film thickness of approximately 1 μm when they applied a layer of cyanoacrylate on a plaster cast and removed the excess with jets of air. Richardson et al[25] found an even thinner film thickness (0.367 μm).

The aim of this study was to assess the dimensional alteration of Type IV plaster fragments bonded with a cyanoacrylate-based adhesive.

Materials and methods

Ten test specimens were made using a hexagonal regular prism 38-mm long and 6.3 mm between the opposite lateral faces as a model. On one of the faces, two transversal grooves were made along the axis with a diamond-milling tool at a distance of 15 mm between them, which served as reference marks. This prism was used as a pattern to make additional silicone molds (Elite HD+; Zhermack SpA, Badia Polesine, Italy) into which the Type IV plaster (Durone, Dentsply Latin America, Rio de Janeiro, Brazil) was poured. The plaster was manipulated according to the manufacturer's specifications, in the proportion of 100 g powder, weighed on a precision electronic balance (Tanita Corporation, Tokyo, Japan), to 19 ml distilled water, measured in a graded pipette. The material was initially spatulated manually and later in a vacuum spatulator. A waiting time of 1 hour was allowed for the material to set before separating the test specimens (Fig 1) from their respective molds.

After this, a digital comparison microscope with a digimatic micrometer head (TM 500, Mitutoyo Corporation, Tokyo, Japan) was used to measure the exact distance between the two reference marks on each of the test specimens. A rigid silicone base was custom made and fixed to the microscope table to ensure the specimens would be aligned with the micrometer's X-axis (Fig 2). The measurement reference line inside the microscope lens was positioned at the margin of the groove of the first mark on the specimen. At this point, the digital micrometer was set to 'zero.' After that, the measurement reference line of the microscope lens was carried to the margin of the groove of the second mark. This was done by turning the screw of the micrometer's X-axis, which could be carried along the same axis of the specimen. The Y-axis micrometer was kept locked. After that, it was possible to determine the distance between the two marks from the reading of the digital micrometer. The measurements were performed between the internal angles of the grooves, with the vertical line of the microscope positioned at the most internal point of the marks (Fig 3). Each measurement was performed three times, and a mean value was calculated from these data.

After measuring the intact test specimens, they were manually fractured such that the fracture line would be between the two reference marks (Fig 4). All specimens were fractured into two pieces, and the fracture line was sufficiently clear to allow the two pieces to fit well. Afterwards, a drop of a liquid cyanoacrylate ester-based universal adhesive (Super Bonder Precisão, Loctite, São Paulo, Brazil) was applied on one

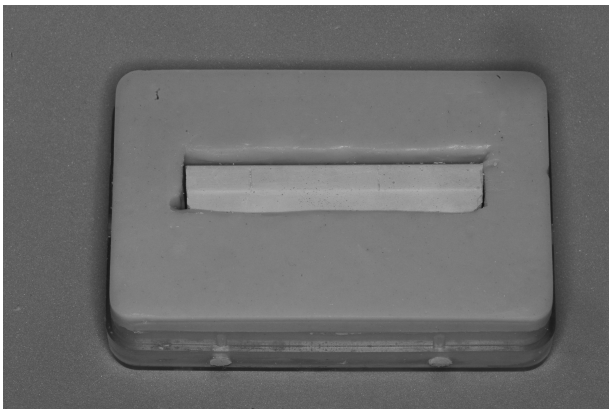

Figure 2 Silicone base with test specimen.

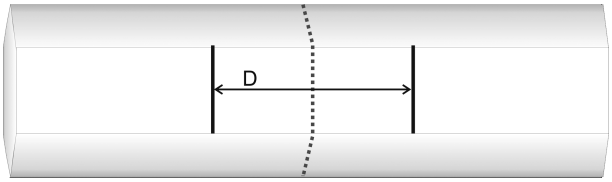

Figure 3 Measurement process.

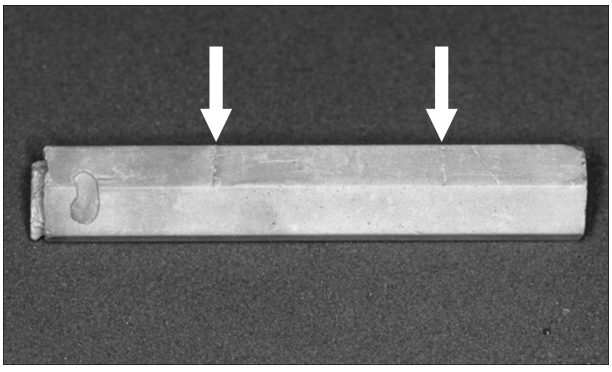

Figure 1 Test specimen with the two reference marks (arrows).

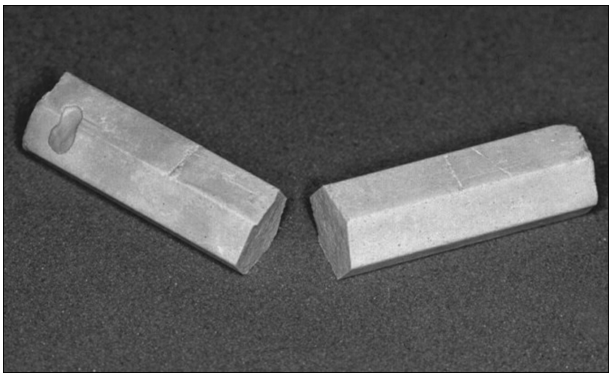

Figure 4 Test specimen fractured between the two reference marks.

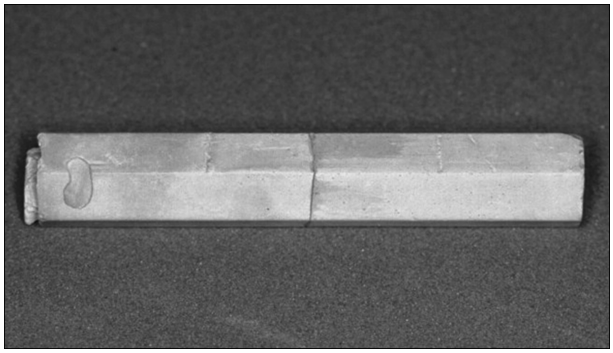

Figure 5 Test specimen bonded with a cyanoacrylate ester-based universal adhesive.

of the faces of the fragment. The two fragments were then manually repositioned and kept in position until the adhesive was completely dry (Fig 5).

After bonding, the test specimens were again placed under the comparison microscope to make a new measurement between the reference marks. The silicone base fixed to the microscope table ensured that the test specimens were always located in the same position under the comparison microscope, enabling the measurements to be performed at the same points, both before and after the specimens were bonded. Three more measurements were made to calculate a mean value. The *t*-test for dependent samples (paired *t*-test) was used for statistical analyses.

Results

Table 1 shows the results of the three measurements of each test specimen, before and after being fractured and bonded with the adhesive. The mean of these three measurements and the paired *t*-test results are shown in Table 2. The mean of the measurements taken before the test specimens were fractured was 15.746 mm, whereas the mean after fracture and bonding was 15.765 mm. The mean difference between the measurements taken before and after fracture and fragment bonding was 0.0194 mm. At a level of significance of 0.05, there was no statistically significant difference between the measurements before and after fracture and bonding of the test specimens ($p = 0.1582$).

Table 1 Measurements of each test specimen, before and after being fractured and bonded with the adhesive (mm)

Specimen	Before	After
1	15.651	15.828
	15.784	15.813
	15.794	15.848
2	15.705	15.834
	15.833	15.738
	15.826	15.763
3	15.772	15.778
	15.775	15.799
	15.780	15.775
4	15.739	15.805
	15.786	15.767
	15.686	15.771
5	15.761	15.788
	15.781	15.815
	15.787	15.775
6	15.866	15.692
	15.624	15.692
	15.615	15.686
7	15.709	15.709
	15.682	15.695
	15.691	15.760
8	15.707	15.741
	15.724	15.767
	15.731	15.762
9	15.811	15.827
	15.744	15.848
	15.733	15.774
10	15.771	15.705
	15.758	15.736
	15.751	15.672

Discussion

The results found in this study confirm the findings of Springmann and Vieira[7] and Hanson et al;[8] that is, bonding of plaster fragments with cyanoacrylate causes minimal dimensional alterations. The mean difference of 0.0194 mm found in this study was even lower than the values found in previous studies, possibly because they included other adhesive agents and not only cyanoacrylate. Likeman and Paolinelis[9] concluded that angular displacement between plaster fragments contributes significantly to the measured displacement distance of fractured teeth bonded to stone casts. The present study, however, did not measure the angular displacement of the fragments.

When cyanoacrylate is applied on the plaster surface, it penetrates into the pores of the crystalline structure,[23] which explains why it is capable of forming a thin layer between the bonded segments.[21,22,25] The fact that a liquid adhesive was used in this study may have facilitated its flow and penetration into the plaster pores, contributing even further to the dimensional alteration being small. It is not known whether a gel adhesive would produce the same results. Further, care was taken to use a recently opened adhesive bottle because it is known that if the bottle remains open for 30 days, then film thickness may be altered.[24]

There are a few limitations of this study. During the measurement process, the vertical line of the microscope was visually positioned on the reference marks, and it could possibly have introduced a certain error. To minimize this, three measurements of each specimen were taken. Moreover, the zoom of the microscope was sufficiently high to keep the possible error to a minimum. The load necessary to fracture the specimens and the quantity of adhesive were not controlled, because our aim was to simulate how clinicians usually repair plaster casts after accidentally fracturing them. Repositioning of the fragments was also not standardized, but the fracture line was clear and allowed only one position of the fragments, at least visually.

Table 2 *t*-test for paired samples

	Paired difference							
				95% Confidence interval of the difference				
	Mean	SD	SEM	Lower	Upper	*t*	df	Sig. (2-tailed)
Distance of intact specimens – Distance of fractured specimens	-1.9×10^{-02}	3.9873×10^{-02}	1.2609×10^{-02}	-4.8×10^{-02}	9.12×10^{-03}	−1.539	9	0.158

This study assessed only one type of plaster, Type IV. As it has been shown that different types of plaster respond in a different manner to different adhesive agents,[7] it is necessary to assess the behavior of cyanoacrylate when applied to other types of plaster. Finally, it would be interesting for this study to be conducted in vivo, and to fabricate dentures on repaired casts, to make a true assessment of whether the small dimensional variation found would cause any clinically significant changes.

Conclusion

Based on the methodology used, it may be concluded that bonding of Type IV plaster fragments with a cyanoacrylate-based adhesive did not cause significant dimensional alterations.

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