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SCIENTIFIC SECTION

A clinical comparison of bracket bond failures in association with direct and indirect bonding

S. Thiyagarajah
Department of Orthodontics, School of Dentistry, Birmingham, UK

D. J. Spary
Queens Hospital, Burton upon Trent, UK

W. P. Rock
Department of Orthodontics, School of Dentistry, Birmingham, UK

Objective: To compare bond failure rates between direct and indirect techniques for bonding orthodontic brackets.

Design: A two-centre single blinded prospective randomized controlled clinical trial.

Materials and methods: This study was undertaken at the Birmingham Dental Hospital and Good Hope Hospital, Sutton Coldfield. Thirty-three subjects meeting the inclusion criteria were selected from orthodontic waiting lists and assigned to either of two study groups according to a split-mouth study design. The number and site of bracket failures between tooth types was recorded over 1 year. Statistical analysis was carried out using chi-square tests.

Results: Brackets were lost from 14 of the 553 teeth bonded, giving an overall bond failure rate of 2.5%. There were no significant differences in bond failures between direct and indirect bonding or in the tooth types of the failures.

Conclusions: There was no significant difference in the bond failure rates between direct and indirect bonding.

Key words: Bracket bonding, randomized clinical trial

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Introduction

Accurate bracket placement is essential to the proper functioning of a pre-adjusted appliance and this may be aided by the indirect bonding technique, which involves placement of brackets in optimal positions on plaster models of the patient's dentition, and then transferring them to the mouth via a tray so that they can then be bonded to the teeth in positions predetermined in the laboratory.

Silverman and Cohen[1] first described the method, using a methylmethacrylate adhesive in combination with light-cured bis-GMA resin. The later Thomas technique[2,3] advocated placement of resin paste onto the bracket bases as part of the laboratory procedure. A transfer tray was made from flexible material that preserved the bracket positions on the model teeth and the set composite was bonded to the teeth using a two-part unfilled resin.

However, a disadvantage of chemically-cured resins is that the uneven rate of polymerization produced by loading the bracket bases at different times may produce an increase in air inclusions within the adhesive.[4] The use of opaque trays also meant that only self-cured composites could be used and improper seating of the tray was not revealed until after tray removal. The development of transparent trays[4–6] made possible the use of light-cured composites, which are more easily removed from around the brackets after setting.[5]

The next stage of development was the use of adhesive pre-coated brackets, which made efficient use of laboratory time and kept contamination to a minimum.[7–9]

A heat-cured fluoride-releasing indirect bonding system has also been described,[10] although several clinicians who used this technique have reported problems with bracket float while heating the resin, since the models have to be heated to 350°C for 30 minutes in order to cure the resin. Furthermore, as ceramic brackets cannot be exposed to such heat, they could not be placed at the same time as metal brackets.[8] Special indirect bonding adhesives are now available for

Address for correspondence: Dr W. P. Rock, School of Dentistry, St. Chad's Queensway, Birmingham, B4 6NN, UK.
Email: w.p.rock@bham.ac.uk

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final positioning of brackets on the teeth. These adhesives are chemically-cured and have short working times, the argument being that light-cured composites are not needed at this stage as an unlimited working time is not necessary.

The use of antisialogogues has been recommended to reduce moisture contamination when using the indirect bonding technique.[2,8] Moisture control is also improved if the transfer tray is correctly trimmed so that it does not extend further on the model than the gingival margins of the teeth.[4]

Two clinical trials have compared bond failure rates using indirect and direct bonding techniques. In one study, 2.5% of directly bonded brackets were lost, while 14% of indirectly bonded brackets failed.[11] The indirect technique was considered inferior due to the greater number of brackets lost, and also because of the increased time required for bracket placement and removal of excess adhesive flash around the bracket bases. The higher failure rate was thought to be due to the chemically-cured composite adhesive used and to technique variations. Composite was placed onto the bracket bases in the transfer tray immediately before this was seated in the mouth so that poor adaptation or uneven pressure may have produced an uneven thickness of adhesive, resulting in decreased bond strength and, therefore, an increased failure rate.[4]

A second study used a chemically activated bonding system and assessed bracket failure after 3 months. Fewer brackets were lost than in the previous study, failure rates being 4.5% for the indirect technique and 5.3% for the direct technique.[12]

A laboratory study using the Thomas technique compared bond strengths for the two bonding methods using 41 extracted human premolar teeth in combination with a self-cured composite.[13] Although 65% of the indirectly bonded teeth had marginal voids, there were no significant differences in bond strengths between the two groups.

In another study, an overall bracket loss rate of 6.5% was found over a period of 30 months when 407 brackets were placed indirectly using a light-cured adhesive.[4] These results are comparable with those obtained in previous trials, which compared light-cured materials with chemically activated composites and found similar overall bond failure rates.[14,15]

Finally, a clinical comparison of two chemically-cured adhesives with the indirect bonding technique resulted in an overall failure rate of 5.6%.[16]

In view of such variations in previous studies, the aims and objectives of this study were therefore to:

- test for differences in bond failure rates between direct and indirect bonding techniques;
- test for differences in the tooth type of bond failures between the two techniques.

Materials and methods

Study design and sample selection

This was a two centre prospective randomized controlled trial in which one clinician bonded all brackets for 33 consecutive subjects aged between 12 and 15 years with a variety of malocclusions. Subjects were selected from the fixed appliance waiting lists at the Birmingham Dental Hospital and Good Hope Hospital, Sutton Coldfield and treatments began between April 2002 and March 2003. No potential subject refused consent. Subjects were included if they required orthodontic treatment with full upper and lower pre-adjusted edgewise appliances and the teeth to be bonded showed no signs of caries, large restorations, fluorosis, hypoplasia or abnormalities of crown morphology, which may have affected bracket bonding.

Sample size was based on the number of teeth needed to demonstrate statistically significant differences between direct and indirect bond failures and was determined using a sample calculation software package, nQuery®. Using data from two previous studies of similar design[12,17] the proportions of bracket failures in directly and indirectly bonded groups, respectively, were estimated to be 0.033 and 0.107. It is acknowledged, however, that ultimately analysis was based on quadrants (dependent units) within individuals (Figure 1), but as noted by Mandall *et al.*[20] there is little useful data available as only three trials were identified which met all the criteria with which to compare. Based on the difference in these proportions (odds ratio of 3.511), a two group continuity corrected chi-square test suggested a sample size of 271 teeth per group at the $P<0.05$ significance level and a power of 90%.

Subjects who fulfilled the inclusion criteria were enrolled into the study and consecutively allocated a number at the time of record collection. A CONSORT diagram showing the flow of participants through each stage of the study is shown as Figure 2. Subjects were randomly allocated into one of two split mouth designs using a randomization table, as shown in Figure 1.[17]

Allocation to a group was made randomly to reduce the possible effect of variability in cooperation and access in individual subjects as well as any operator bias (e.g. a right-handed operator may find it easier to bond the right hand side of the mouth).

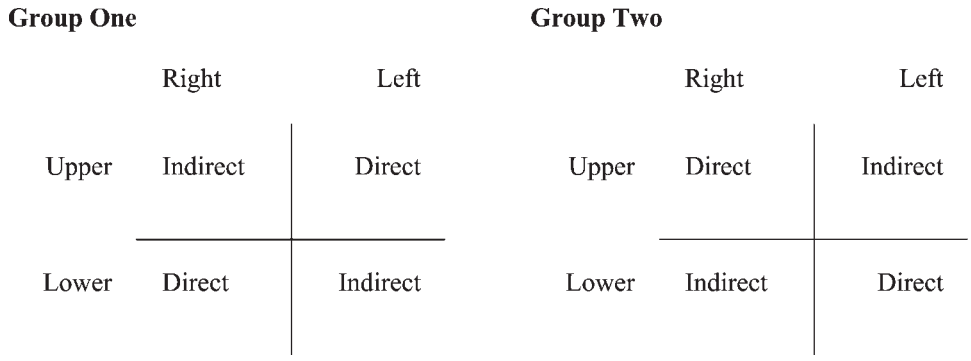

Figure 1 Split-mouth design

The randomization table was also used to decide the order in which quadrants were bonded in order to avoid bias that may have arisen from using the same technique first in every subject.

Data analysis

Between-group differences were examined using chi-square. When analyzing the data we had a large number in each group and the statistician advised that a continuity correction would not have an impact. It was therefore not used as it had been during sample size calculation when numbers were unknown.

Ethical approval

Ethical approval was obtained by North and South Birmingham local ethics committees (LREC 655.02 and LREC 0835). Parents were given an information leaflet and written consent for entry into the trial was also obtained.

Record collection

A split-mouth design was randomly allocated at the time working records were taken and subjects were treated consecutively.

The indirect bonding technique (laboratory stage)

Models were cast on the same day as impression taking to ensure accurate fit of the transfer trays and trimmed so that they were no higher than 2 cm, to allow easy use of the vacuum forming apparatus.

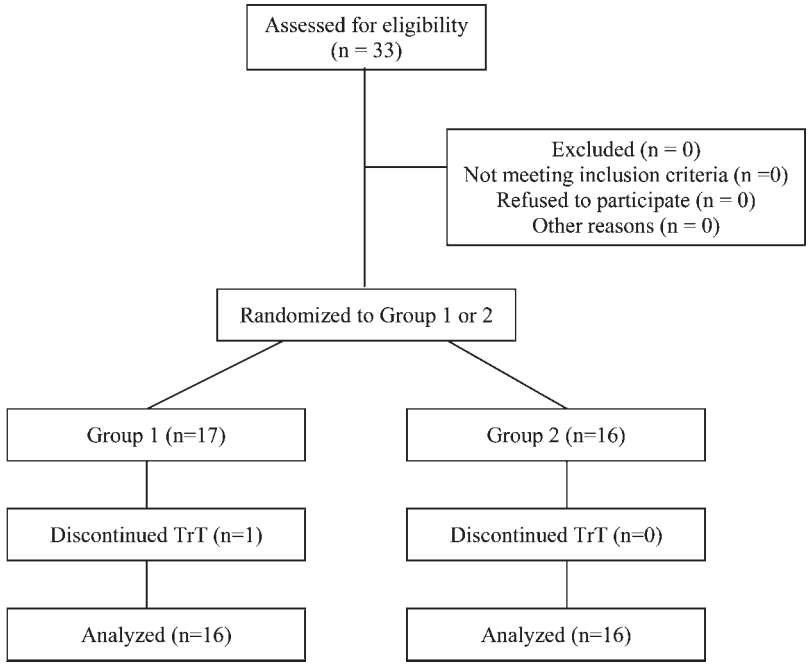

Figure 2 A CONSORT diagram showing the flow of participants through each stage of the trial

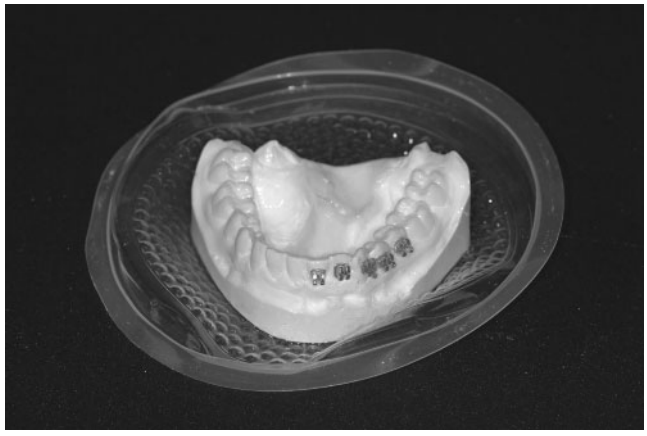

Figure 3 A tray blank adapted to a model

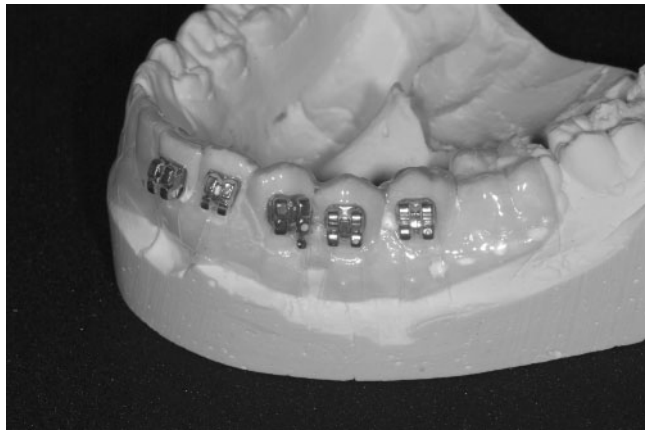

Figure 4 A completed tray

Quadrants to be indirectly bonded were marked with vertical and horizontal pencil lines on each tooth to identify the LA point.[18]

The appropriate pre adjusted edgewise bracket (MBT™ Versatile + Bracket System) was selected for each tooth and a small amount of 3M Unitek laboratory adhesive was placed onto the base. Each bracket was then positioned on its tooth and the adhesive was allowed to dry for at least 1 hour before the next step.

Trays were made using a 0.45 mm thick blank of Drufolen W™ transparent tray material. The transparency of the material allowed the use of light curing, which gave better control of working time. A circular blank was draped over a dry model and brackets. The blank was first heated and then closely adapted to the model by means of negative pressure using a vacuum forming apparatus (Drufomat™; Figure 3). After the Drufolen had cooled it was trimmed with a hot instrument and removed from the model along with the brackets that were contained within it. Finally, the tray was trimmed close to the gingival margins of the teeth and two vertical slits were made from the edge of the tray to the mesial and distal gingival wings of each bracket in order to facilitate removal from the mouth (Figure 4).

Preparation for bonding

A similar method was employed to prepare the teeth for bonding whether a direct or indirect technique was to be used. Each quadrant of teeth was prepared and bonded separately to minimize the risk of moisture contamination. Teeth were polished for 5 s each using a bristle brush in a slow speed hand piece with a slurry of pumice and water. The teeth were then rinsed with an air/water spray until all traces of pumice had been removed. A cheek retractor and a flexible saliva ejector were used for moisture control, and cotton wool rolls were placed in the buccal and lingual sulci to improve isolation. The teeth were then dried with oil-free compressed air for 5 s each and etched for 20 s with DeTrey® Conditioner 36 containing 36% phosphoric acid, in accordance with the manufacturer's instructions. Each tooth was then rinsed thoroughly for 15 s until all traces of the blue etching gel were removed before they were dried again with oil-free compressed air until they exhibited a frosty white appearance with no traces of moisture.

The indirect bonding technique (clinical stage)

Following the steps above a thin layer of Transbond™ XT primer was applied to the bracket bases and to the teeth in the quadrant to be indirectly bonded. A small amount of Transbond™ XT light cure orthodontic adhesive was placed onto the base of each bracket and the tray was seated with even pressure to allow good adaptation of the brackets to the teeth and an even thickness of composite resin (Figure 5). Molar bands were fitted in all four quadrants only after bracket placement, to ensure that accurate seating of the tray was not prevented.[8]

Care was taken to place a minimum amount of composite resin onto each bracket base to avoid excessive adhesive flash. Each bracket was cured using a standard light source for 20 s, 10 s on the mesial and 10 s on the distal aspect. Brackets were cured starting with the most posterior tooth, then moving forwards and the tray was then carefully removed using a flat plastic instrument (Figure 6). Excessive adhesive flash was removed using a Mitchell's trimmer and rotary instruments if necessary.

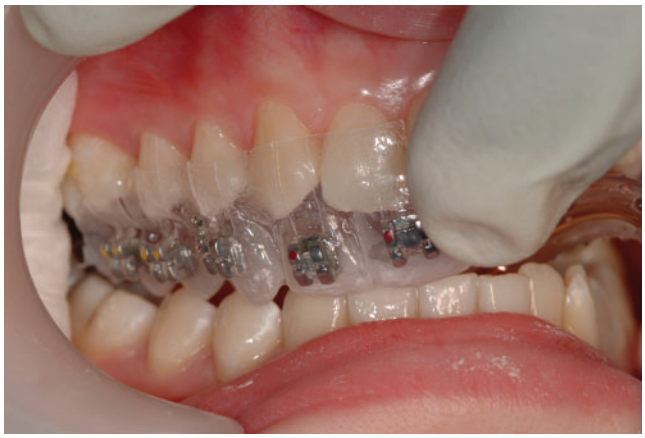

Figure 5 Placement of a tray in the mouthTray removal

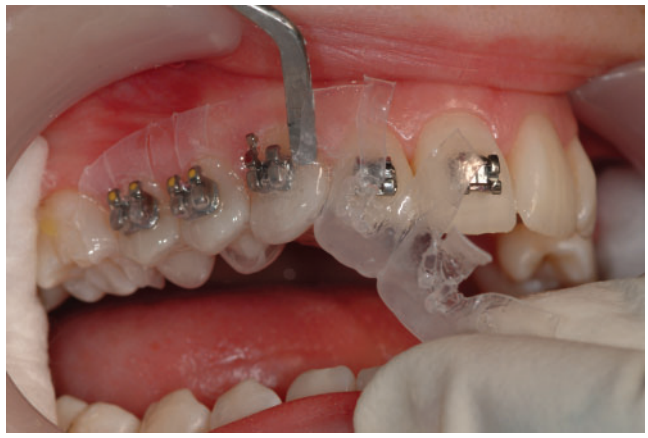

Figure 6 Placement of a tray in the mouthTray removal

The direct bonding technique

The teeth were prepared as before and Transbond XT™ primer was then painted onto each tooth and bracket base. A small amount of Transbond XT™ composite was applied to each bracket base and the bracket was then positioned onto the LA point of the tooth. All brackets in the quadrant were positioned and excess composite was removed before the curing light was applied. Each bracket was cured for 20 s, 10 s on the mesial and 10 s on the distal aspect.

To minimize variation in the magnitude of orthodontic forces applied to the teeth, a similar initial 0.014-inch nickel titanium archwire was used in each case. At each visit, a record was kept of the tooth type, date and circumstances of bracket bond failures. Only first time bond failures were recorded since it has been recommended that clinical studies evaluating bond failure rates should either only record first time failures or analyze multiple failures at the same site in a different category.[20] All subjects were observed over a period of 1 year.

Results

Thirty-three subjects entered into the trial with a mean age of 13 years and 7 months. One subject discontinued treatment, leaving 32 to complete the study. Five-hundred-and-sixty brackets were bonded. Seven of the brackets placed indirectly required rebonding at the time of placement and these were not included in the results. Omission of these immediate bracket failures left a total of 553 brackets of which 14 were lost over the year, an overall failure rate of 2.5% (Table 1). Bond failure occurred for six indirectly bonded brackets and eight direct bonds, the difference was not significant, chi-square=0.331, P=0.565. Inclusion of the seven early bond failures would have altered the statistical significance of the between group difference only slightly chi-square=1.025, P=0.311)

Due to the small number of bracket failures, data were subdivided into incisors, canines and premolars, rather than individual teeth. Comparisons were made between the upper and lower arches, and the right and left sides of the mouth.

Overall, there were eight bond failures on incisors and six bond failures on premolars (Table 2). There were eight bracket failures in the upper arch and six failures in the lower. Premolar bracket failure was equal in both arches (three) and there were no canine bracket failures. There were five incisor bracket failures in the upper arch and three in the lower. There were six failures on the right side of the mouth and eight failures on the left.

Four directly bonded brackets failed in the upper arch and four failed in the lower. Three of the direct bond failures were on the right side of the mouth and five on the left. Five of the direct bond failures were on incisor teeth and three on premolars (Table 2).

After indirect bonding, four brackets were lost in the upper arch and two from the lower. Three brackets were lost from each side of the mouth and three brackets were lost from both incisors and premolars (Table 2).

Sixty-six per cent of the failures following indirect bonding occurred in the first 6 months, while with the

Table 1 Bond failures with direct and indirect bonding

	Bonds survived		Bonds failed	
	No.	%	No.	%
Indirect bonding	273	97.8	6	2.2
Direct bonding	266	97.1	8	2.9
Total	539		14	

Key: No.=number

direct method, 43% were lost in this same time period. Overall, 50% of the bond failures occurred in the first 6 months after placement (Table 3). The remainder occurred later, thus suggesting a relatively constant hazard.

Discussion

This clinical trial found no significant difference in the number of bracket failures that followed direct and indirect bracket placement, respectively. The study used a split-mouth design in order to remove differences that may have existed between the subjects from comparison of the effectiveness of direct and indirect bonding.[19] A potential disadvantage of the split mouth design is that treatments applied to one side of the mouth may have carry-across effects on contralateral teeth (this situation is avoided if the patient is randomized to a treatment-type[20]). In the present study, the transfer trays, which carried the brackets for indirect bonding contained brackets on one side only. It impossible to say whether this facilitated or complicated tray placement, although the results suggest that there was no effect, since results were similar on the right and left sides of the mouth.

Bond failure rates of 2.2% for the indirect and 2.9% for the direct technique are lower than found in previous studies of indirect bonding, which reported an overall failure rate of 5.6% for two chemically-cured composite bonding resins.[16] The low numbers of bond failures recorded with each bonding system in the present trial may be due to the careful bonding technique employed.

Table 2 Bond failures according to site and bonding method

	Bonds survived				Bonds failed			
	Indirect		Direct		Indirect		Direct	
Site of bond failures	No.	%	No.	%	No.	%	No.	%
Upper arch								
Incisors	61	96.7	58	94.8	2	3.3	3	5.2
Canines	28	0	28	0	0	0	0	0
Premolars	48	95.8	47	97.9	2	4.2	1	2.1
Total	137	97.1	133	97	4	2.9	4	3.0
Lower arch								
Incisors	62	98.4	61	96.7	1	1.6	2	3.3
Canines	31	0	31	0	0	0	0	0
Premolars	49	98	49	95.9	1	2.0	2	4.1
Total	142	98.6	141	97.2	2	1.4	4	2.8
Right/left								
Right	141	97.9	133	97.7	3	2.1	3	2.3
Left	138	97.8	141	96.5	3	2.2	5	3.5

Key: No.=number

Since the numbers of bracket failures were low, only simple statistical analyses have been used in the results section.

Our results are comparable with those of Aguirre,[12] in that there was no statistically significant difference between the number of bond failures following direct and indirect bonding, respectively, although they differ from the finding of Zachrisson and Brobakken who reported a failure rate of 14% for indirect bonding and 2.5% for the direct method.[11]

However, it is difficult to make direct comparisons since this last study used four different combinations of bonding techniques, adhesives and bracket bases for each patient.

Overall bond failure rates for light-cured composites used with a conventional two-stage bonding system have been reported to be between 2.9 and 23% in randomized controlled trials.[14,15,21–23] However, again it is difficult to make direct comparisons of bracket failure rates between different studies due to variations in materials, research design and trial duration.

An observation period of 12 months following bracket placement should give a reasonable estimate of the long-term performance of a bonding system, since other work has shown that most failures occur within the first 6 months.[14]

Indirect bonding technique

When using indirect bonding, it is essential that the correct amount of adhesive is placed on the bracket bases before seating the tray, since subsequent removal of excessive set adhesive flash can prove difficult, especially with chemically-cured composites.[24] Adhesive flash became less of a problem as the operator (ST) became more proficient in the technique.

Care must be taken to seat the tray properly and to apply even pressure over brackets when light curing. Otherwise, there is a danger that an uneven thickness of composite on a bracket base may weaken the bond and lead to bond failure at the time of tray removal.

Table 3 Bond failures in relation to time interval following bonding

	Bond failures			
	Indirect		Direct	
Time following bonding (days)	No.	%	No.	%
0–90	3	1.1	2	0.7
91–180	1	0.4	1	0.4
181–270	2	0.7	4	1.5
271–362	0		1	0.4

Key: No.=number

It has been suggested that an advantage of indirect bonding is its ability to isolate teeth from moisture contamination.[4,14] This is attributed to the coverage afforded by the close-fitting transfer tray, which improves moisture isolation in the posterior segments.

It has been widely recognized for many years that accurate bracket positioning is of critical importance to realizing the full potential of a pre-adjusted edgewise appliance.[25] Indirect bonding allows more accurate bracket placement[14] with less placement variation[26] than is possible when using the direct system.

Conclusions

- There is no difference in bond failure rates between direct and indirect bonding.
- The site of bond failure with regards to tooth type does not vary between the two techniques.

A poster describing this project was awarded the Gunter Russell Prize at the British Orthodontic Conference of 2004.

Contributors

David Spary developed the clinical technique and Peter Rock designed the study. All clinical work was carried out by Shanthi Thiyagarajah, who collected and analyzed the data. Materials were provided by 3M Unitek. Peter Rock is the guarantor.

Acknowledgement

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