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Clinical Experience with an Epoxy Resin Adhesive for Direct Bonding of Orthodontic Attachments*

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SUMMARY

An epoxy resin formulation developed in the Dental Research Unit has been subjected to further clinical trials. Six patients, were used in the study. They were divided into two age groups and all the teeth, including the first molars, bonded. Rubber dam was used to keep the crowns dry during the setting period of the resin. In the younger group the mean failure rates were 27 per cent for anterior teeth and 70 per cent for the first molars. In the older group these rates were 11 per cent for incisors, 11 per cent for canines, 20 per cent for premolars and 20 per cent for first molars. While no figures are available in the literature relating to direct bonding to first molars, the results obtained in this study for the other teeth compare favourably with data previously published by other authors after trials using other types of cement.

OPSOMMING

'n Epoksie hars formulering wat in die Tandheelkundige Navorsingseenheid ontwikkel is, is aan verdere kliniese proefneming onderwerp. Ses pasiente, verdeel in twee ouderdomsgroepe, is vir die kliniese studie uitgesoek en die ortodontiese aannegtings aan al die tande, insluitende die molare, direk verbind. Kofferdam is gebruik om die krone van die tande droog te hou gedurende die tydperk wat die hars set. In die jonger groep het 27 per sent van die aanhegtings aan die voorste tande gefaal en 70 per sent aan die eerste molare. In die ouer groep was die persentasie aanhegtings wat misluk het 11 per sent vir snytande, 11 per sent vir oogtande, 20 per sent vir premolare en 20 per sent vir eerste molare. Terwyl geen syfers in die literatuur beskikbaar is in verband met die direkte verbinding aan eerste molare nie, vergelyk die resultate wat in die ondersoek verkry is vir die direkte verbinding aan ander tande gunstig met gegewens wat deur ander outeurs met verskeie tipes sement in kliniese proefnemings verkry is.

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The bonding of orthodontic attachments, such as brackets, tubes and buttons, directly to the teeth has been investigated by several workers over the past fifteen years (Rose et al, 1955; Sadler, 1958; Newman, 1965, 1969; Mitchell, 1967; Retief and Dreyer, 1967; Mizrahi and Smith, 1969; Retief, Dreyer and Gavron, 1970). Fitting metal bands to teeth in order to receive these attachments is time-consuming, may cause gingival irritation and if cement dissolution occurs may lead to food impaction and eventually to enamel decalcification. The advantages of direct bonding include improved appearance of the appliance and elimination of the need for separation of the teeth.

MATERIALS AND METHODS

The epoxy resin adhesive Epikote 828/Epikure U, as modified by Retief and Dreyer (1967), and Retief, Dreyer and Gavron (1970), consists of two parts, the first containing the epoxy resin and thixotropic agent and the the second the reactive hardener and catalyst (Table I). The main object of the investigation was to assess the reliability of this resin for the direct bonding of orthodontic attachments to all the teeth usually involved in orthodontic treatment, including the first molars.

Additional mechanical retention between the resin and the steel was provided by first welding a backing, consisting of band material carrying a layer of 60 mesh stainless steel gauze, to each attachment. The attachments were then cleaned in 40 per cent sulphuric acid, rinsed in water, dipped in alcohol and finally dried in an oven. The constituents of the first part of the resin were mixed together, then both components of the second part were added. Mixing continued for two minutes, the final compound then spread thinly on the glass slab, the prepared attachment orientated in the resin, and the whole then placed in an oven at 50°C for 6 min.

Tooth surfaces were thoroughly cleaned with pumice, conditioned with 50 per cent phosphoric acid for one minute, and then washed adequately to remove all acid. Moisture adversely affects adhesion of epoxy resins especially during the setting period; hence all teeth were isolated by rubber dam (Fig. 1). The attachments were then positioned on each tooth and permitted a setting time period of 20 min.

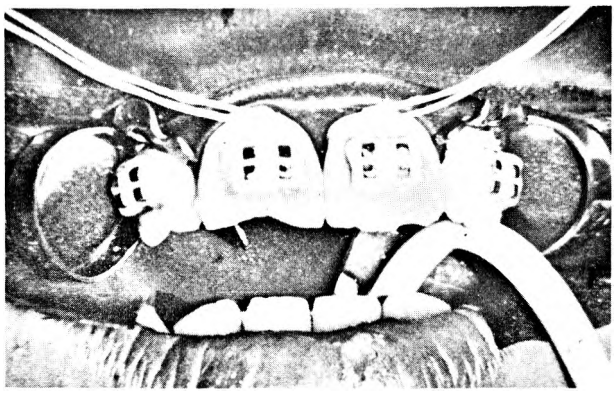


Fig. 1. Isolation of teeth with rubber dam.

When a bond failed, a new attachment was placed on the tooth and the crown kept dry during cementation with a "mini" rubber dam (Fig. 2). When a bond failed twice, the tooth was banded conventionally.

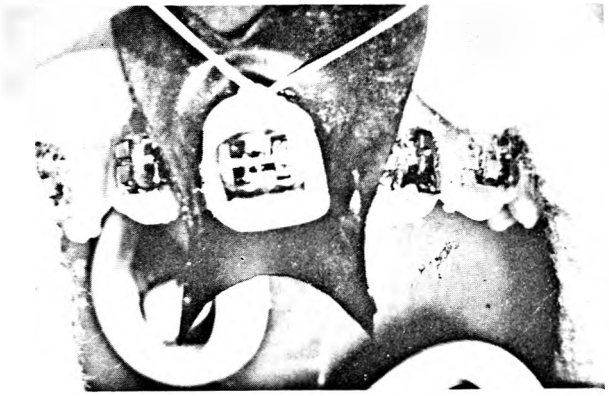


Fig. 2. "Mini" rubber dam.

The patients were divided into 2 groups. The first consisted of young patients ranging in age from 9 to 11 years. In this group, attachments were bonded only to the upper first molars, and when treatment demanded, also to the upper incisors (Table II).

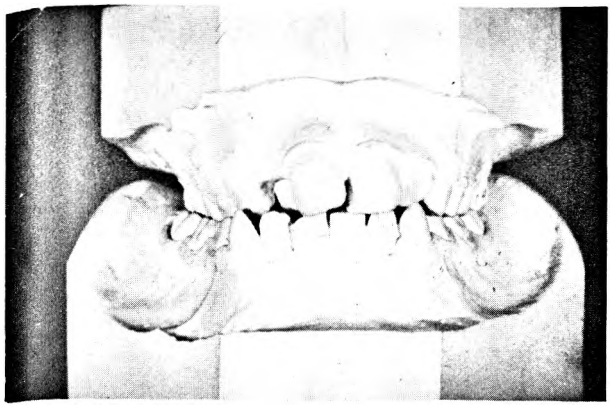
The second group consisted of two older patients aged 15 and 23 years respectively, and here attachments were bonded directly to all upper and lower incisors, canines, premolars and first molars (Table III).

The treatment included the use of a 045 archwire (Boersma and Dijkman, 1970) for correcting posterior crossbite; extra oral-traction for correcting Class II jaw relation, (Dijkman, 1970) and the edgewise arch system for closing extraction spaces (Thurow, 1962). The survey extended over about 12 months.

CLINICAL TRIALS

Patient A, 9 years old, had a Class I malcocclusion with posterior crossbite on the right side, and crowding of the upper and lower anterior segments. The treatment plan comprised extraction of 4 deciduous canines to alleviate the anterior crowding, bonding of attachment on upper molars to allow expansion of the upper arch with an 045 archwire, and bonding of attachments to the upper incisors to permit alignment with round arch wires. The right molar was banded about 2 months after treatment commenced (Fig. 3).

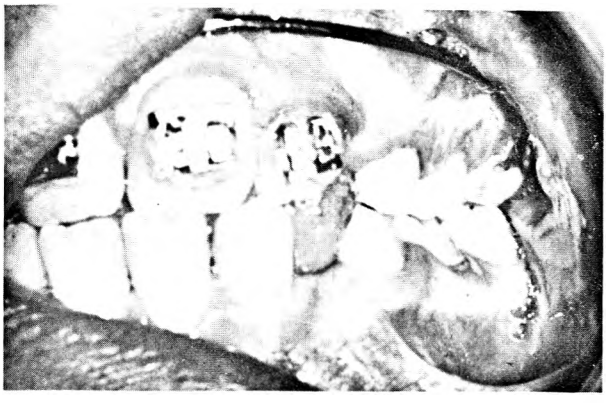
Fig. 3. Patient A.



(a) Class I, with posterior crossbite on the right side and anterior crowding.



(b) The crossbite is corrected with an 045 expansion archwire.



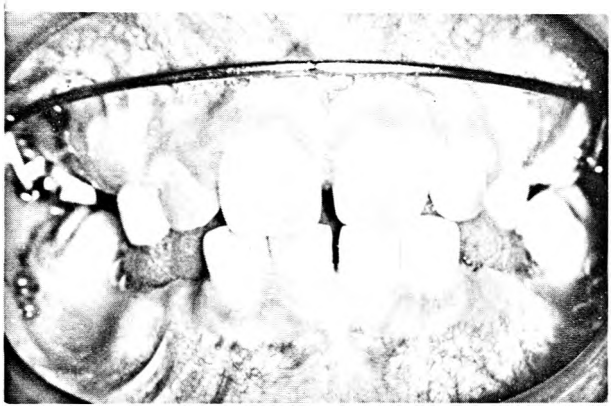
(c) The attachment on the left molar is still in place 8 months after bonding.

Patient B, 9 years old, had a Class I malocclusion with bilateral posterior crossbite mainly due to the premature loss of deciduous molars. Expansion of the upper arch with an 045 archwire was undertaken. The attachment on the right molar lasted for one month before conventional banding was required. Further treatment was postponed, awaiting the eruption of the permanent canines and premolars (Fig. 4).

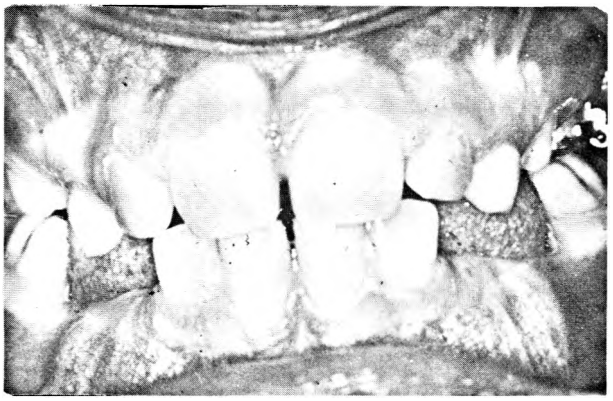
Fig. 4. Patient B.



(a) Class I, with bilateral posterior crossbite.



(b) The crossbite is corrected with an 045 expansion archwire.



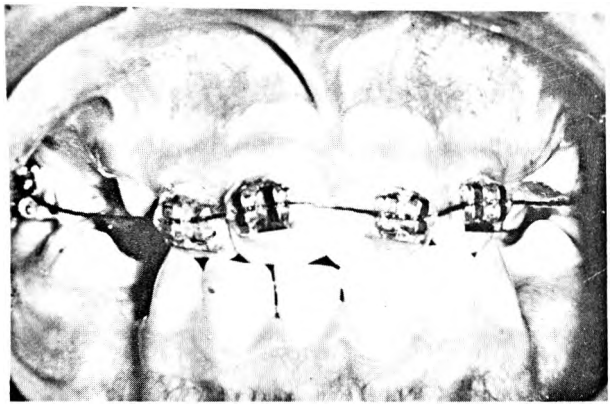
(c) The attachment on the left molar is still in position 8 months after bonding.

Patient C, 10 years old, had a Class I malocclusion with anterior crossbite and considerable arch length discrepancy. The 4 first premolars were extracted. Attachments were bonded directly to the upper molars and the upper incisors. Active protrusion of the upper front teeth was commenced. Further treatment was postponed until the eruption of the permanent canines and second premolars (Fig. 5).

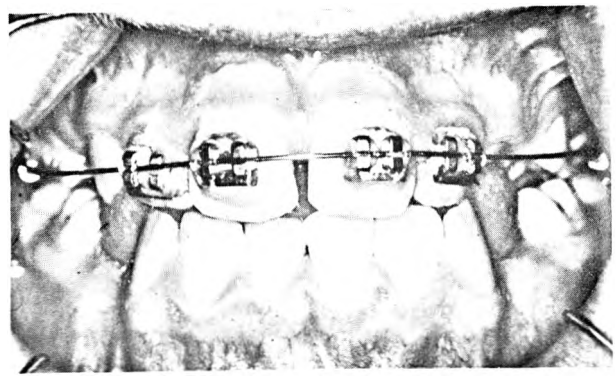
Fig. 5. Patient C.



(a) Class I, with anterior crossbite.



(b) The initial alignment was accomplished with a twist-flex archwire.

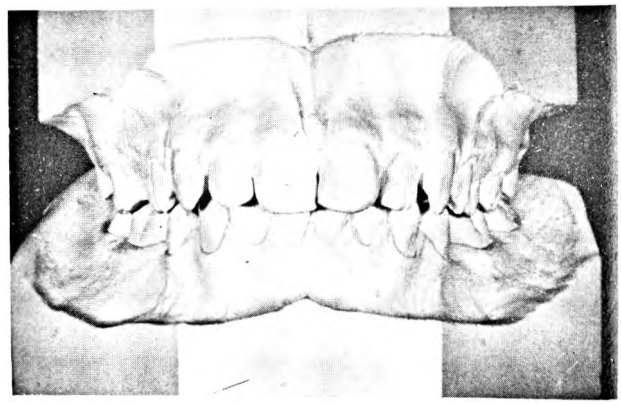


(c) The crossbite was corrected after 8 weeks with an 0,016 inch archwire.

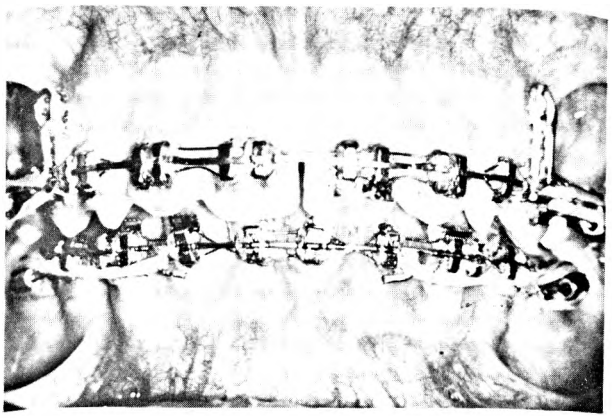
Patient D, 11 years old, had a Class I malocclusion with posterior crossbite on the right side. Attachments bonded directly to the upper first molars received an 045 archwire to expand the arch. Both molars were banded conventionally 12 days after the clinical trial commenced.

Patient E, 15 years old, had a Class II, Division I malocclusion. It was decided to extract all second premolors, and attachments were then bonded to all the remaining teeth except the second molars. The lower second premolars were lingually displaced and the resulting extraction spaces were so small that closure was achieved with round archwires only. In the maxilla, however, the extraction spaces were closed with rectangular archwires. Anchorange was reinforced with a Rampton type of headgear to the upper first molars (Fig. 6).

Fig. 6. Patient E.



(a) Class II, division I malocclusion.



(b) Closing the extraction spaces using a rectangular archwire in the upper jaw and a round archwire with intramaxillary elastics in the lower jaw.



:) Molar anchorage was reinforced, using extra oral traction.

Patient F, aged 23 years had a Class II, Division I malocclusion. Both lower first premolars had been extracted at an early age. The upper first premolars were extracted and attachments were bonded to the remaining teeth from central incisor to first molar. The lower arch was corrected with round arch wires only, while a rectangular closing loop archwire was used to close the extraction spaces in the maxillary arch. A Rampton type of headgear was used for about 5 months (Fig. 7).

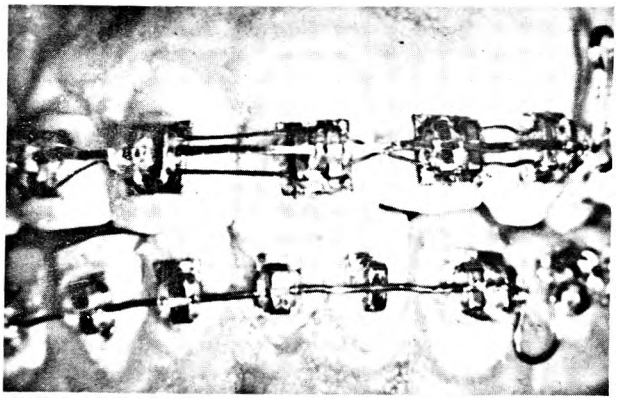
RESULTS

In the younger group molar tubes became detached quite frequently (Table II). Only 4 of the 13 epoxy resin bonded molar tubes were entirely successful (i.e. a failure rate of 70 per cent). In contrast, 8 of the 11 epoxy bonded anterior brackets remained in place (failure rate - 27 per cent). A probable reason for failure was the low clinical crown heights, which lead to direct contact between gum and adhesive during setting, and to bite interference during

Fig. 7. Patient F.



(a) Class II, division I malocclusion.



(b) In the upper jaw rectangular archwires were used to close the extraction spaces.

In the lower jaw this could be done with round archwires.



(c) The anchorage in the upper jaw was reinforced with a Rampton type of headgear.

function. An additional factor that must be considered is the increased flow of fluid at the cervical margins of young, permanent teeth.

In the older group the clinical crown heights were higher, and the overall result was more encouraging Table III.) Of the 10 molar tubes, only 2 became loose (i.e. a failure rate of 20 per cent). Similarly, 2 of 10 premolars brackets (20 per cent), 1 of 9 canine brackets (11 per cent) and 2 of 18 incisor brackets (11 per cent) became detached. Thus the percentage failure rates were distinctly lower in the older group (Table IV); in spite of the fact that in both these patients rectangular archwires and extra-oral tranction were applied to the upper arch.

Table I: COMPOSITION OF THE MODIFIED EXPOXY RESIN

Part I			
Epoxy resin	:	Epikote 828	— 1.12 g (1.0 ml)
Thixotropic agent	:	Aerosil	— 0.10 g
Part II			
Reactive hardener	:	Epikure U	— 0.31 g (0.3 ml)
Catalyst	:	Phenol	— 0.07 g

Table II: Table showing teeth originally bonded, those on which the bond failed (2 figures *above each other indicate 2 failures) and the molars that were finally banded.*

YOUNGER GROUP 9—11 YEARS.

Patient	Teeth Bonded	Attachment Failure	Bands
A	6 21 12 6	6 2 6 21 6	6
B	6 6	6 6 6	6
C	6 21 12 6		
D	6 6	6 6 6 6	6 6

Table III: *Table showing the teeth originally bonded. Bond failures are indicated by the figure of the tooth involved. No bands were placed in this older group.*

OLDER GROUP 15—23 YEARS.

Patient	Teeth Bonded	Attachment Failure	Bands
E	6 4321 1234 6 6 4321 1234 6	43 1 4 6	
F	65 321 123 56 65 321 123 56	6 1	

Table VI: PERCENTAGE FAILURE RATES

	Incisors	Canines	Premolars	Molars
Younger group	27	—	—	70
Older group	11	11	20	20

Table V: COMPARATIVE PERCENTAGE FAILURE RATES

	Incisors	Canines	Premolars	Molars
Present study	11	11	20	20
Miura *Et Al* (1971)	2		11	—
	6			
Mizrahi Smith (1971)		12		—

DISCUSSION

Whenever a bonded attachment became dislodged, failure of the bond occurred at the adhesive-enamel interface. The added mechanical retention obtained by welding the stainless steel gauze to the attachment prevented the break occurring at the epoxy-stainless steel interface.

Among the many factors affecting adhesion the forces exerted on the bracket and the effect of moisture must be considered (Retief, 1970 a,b).

The forces acting on the attachments are derived from the surrounding soft tissues, from masticatory activity, and from orthodontic wires. Forces produced by the soft tissue (Gould and Picton, 1964) and the applicance (Storey and Smith, 1952), usually do not exceed one kg whereas the biting force in the natural dentition may range from 10 kg to 100 kg (Howell and Manley, 1948). Previous laboratory tests had demonstrated that a tensile strength of up to 70 kg per cm^2 was obtained by our epoxy resin (Retief and Dreyer, 1967). Thus it may be considered that bond breakage was due mainly to masticatory stresses. This is supported by the fact that many of the attachments that became loose did so within the first few days after bonding the attachments and before the arch wires were engaged.

The earlier the curing epoxy resin comes into contact with water, the greater the adverse effect on the adhesion of the resin. The water that affects the adhesion may be derived from the saliva, gingival crevice and the pulp of the tooth. The most obvious changes produced by water on the curing resin occurred in the superficial layers which became white and brittle (Retief and Dreyer, 1967). In this study the saliva and fluid from the gingival crevice were controlled by means of rubber dam for the first twenty minutes setting time.

Bergman (1963) demonstrated the flow of fluid from the pulp of a tooth to the enamel surface. He showed that this flow occurred spontaneously and is not dependent on an increased intra-pulpal pressure. Linden (1968) found that the fluid flow was faster in young, permanent teeth and observed that the cervical area exhibited a more rapid flow that the rest of the crown.

Recently two articles on direct bonding have been published. Miura, Nakagawa and Masukara (1971), using methacryloxypropyl tri-methoxysilane liner and a modified methacrylate resin with tri-n-butyl borane as catalyst, showed failure rates of 2 per cent for upper anterior teeth, 6 per cent for lower anterior teeth and 11 per cent for premolars. Mizrahi and Smith (1971), using a zinc polyacrylate cement, showed mean failure rates of 12 per cent (Table V). Molars had been banded conventionally in both studies.

The direct bonding of orthodontic attachments to molar teeth have not previously been reported. In the younger age group the failure rate was high but much more encouraging results were obtained in the older patients. The results obtained in this study for other teeth are comparable to the data previously published after trials using other types of cement.

The direct bonding of orthodontic attachments has not yet become an accepted clinical procedure in orthodontic practice. Despite the encouraging results obtained with the older patients in this study, the authors have encountered a number of problems which still remain to be solved.

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