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An investigation into the use of an anaerobic adhesive with two commercially available orthodontic brackets

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Summary *Objectives*. The two objectives of this experiment were to determine the surface temperature of enamel following acid etching, rinsing and drying, and to see whether two commercially available orthodontic brackets could be bonded to enamel using an anaerobic adhesive.
Methods. Enamel surface temperature was determined in vivo using a surface temperature probe on a total of 60 patients. Stainless steel orthodontic brackets were bonded to human enamel using an anaerobic adhesive and a control orthodontic adhesive. The enamel was etched prior to bonding either with a solution of 37% *o*-phosphoric acid or, in the case of the anaerobic adhesive specimens, with a solution of 37% *o*-phosphoric acid containing copper (II) chloride. After bench curing the specimens were shear bond tested to failure and the load at debond recorded in each case.
Results. The bond test results were analyzed using median force to debond (N) and 95% confidence intervals, Kaplan–Meier survival probabilities and log-rank tests.
Conclusions. After etching rinsing and drying the enamel surface temperature ranged from 21.54 to 24.19 °C, which is within the range suitable for anaerobic adhesive use. Bond testing to failure demonstrated that bracket base design affected the measured force to debond with both the anaerobic adhesive under test and the control adhesive. In addition, the anaerobic adhesive was affected by the material composition of the bracket base and curing time. After 1 h of curing and using the Miniature Twin bracket, the measured force to debond exceeded the 10 min force to debond results of the control adhesive.
Significance. It is possible to bond commercially available orthodontic brackets to teeth using an anaerobic adhesive.

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Introduction

The bonding of orthodontic brackets to teeth has been common practice for over 30 years, since the description of the acid etch technique by Buonocore [1] and its use in orthodontics by Newman [2] and Mitchell [3]. However, whether the adhesive used is diacrylate based or a glass polyalkenoate with or without resin modification, it always requires either chemical or light activation. Chemical activation necessitates more than two components to the adhesive system, whilst light activation requires the separate use of the curing light. The panacea for orthodontic and indeed dental bonding would be a single component adhesive requiring no surface pre-treatment of either the bracket base or tooth enamel. Cyanoacrylates would at first seem to meet this single component requirement, but have been shown to be unsuccessful bonding agents [4] due to hydrolytic degradation at the bondline. A step closer to this single component ideal might be seen with the use of anaerobic adhesives. These are single component diacrylate adhesives which are substrate surface activated and require no premixing. The most effective transition metal able to activate their polymerization is copper. Industrial applications of such adhesives usually require that both bonding substrates are either made from a transition metal or are at least coated with a copper salt prior to bonding [5]. Within dentistry it has previously been demonstrated that copper cylinders can be bonded to conventionally acid etched enamel using anaerobic adhesives [6] and that the copper content of such cylinders will have a direct effect on the rate of polymerization [7]. In both cases bonding was achieved with only one surface being reactive, namely the metal cylinders. If the cylinders are made from steel, which is fairly unreactive towards anaerobic adhesives, they can still be bonded to acid etched enamel by instead rendering the enamel surface reactive. This is achieved by the addition of copper salts to the etchant, either copper chloride or copper sulphate [8,9]. In addition to being dependent on the presence or absence of a transition metal substrate and anaerobic conditions, the polymerization of single component anaerobic adhesives is also temperature dependent. A reduction in the substrate temperature from 20 to 25 °C down to 10 to 15 °C can halve the reaction rate, which would have important consequences for prospective clinical use. The reactivity of the adhesive can be adjusted to reduce the effect of temperature, but a balance has to be struck between the working time and shelf life of the adhesive.

The previously reported work on anaerobic adhesives has investigated the bonding of custom made metal cylinders to teeth, where the rim of the cylinder closely approximates an etched, but specially flattened enamel surface. In this way a sufficiently anaerobic environment can be created beneath the custom made base to ensure polymerization of the adhesive [6,8,9]. What is unknown then is whether commercially available stainless steel orthodontic brackets can be bonded to teeth of normal anatomy using the same anaerobic adhesive and where such a close fit of the base to the enamel surface is unlikely. The use of an anaerobic adhesive in this instance will still require an etched enamel surface to provide mechanical adhesion. It is also unknown at what temperature this is likely to occur in the mouth.

The aims of the current experiment were therefore twofold. Firstly, in an in vivo experiment the surface temperature of enamel was to be determined following acid etching, rinsing and drying. Secondly, in an in vitro investigation, the aim was to see whether two commercially available orthodontic brackets could be bonded to teeth of normal anatomy using an anaerobic adhesive and to compare this to a conventional orthodontic bonding adhesive.

Materials and methods

This investigation was divided into two parts; an in vivo investigation to determine enamel surface temperature, and an in vitro investigation to determine whether commercially available orthodontic brackets could be bonded to enamel using the anaerobic adhesive Perma Metal (Permabond, Eastleigh, Hants, UK) and at the same temperature as is found clinically.

Many anaerobic adhesives are designed to cure on active surfaces in the 20–25 °C temperature range. The purpose of the first part of the experiment was to measure the in vivo enamel surface temperatures of both unetched and etched teeth, in order to see whether the latter in particular falls within the optimum temperature range for anaerobic adhesive use.

The permanent teeth on which the temperatures were measured were the upper right central incisor, the upper right canine, and the upper right second premolar. These teeth were chosen in order to see whether there was any temperature