The optimisation of orthodontic bracket adhesive regimes to improve patient treatment.

Simon Hobson and M. J . German*

Newcastle University

COHR Centre for Oral Health Research

Aim

- To establish whether the acid-etching step or priming step has the greatest influence on the bond strength of orthodontic brackets to human teeth.

Introduction

- The main aim of orthodontics is to alter the alignment of teeth so they better match the ideal dental arch and so improve patient quality of life.
- Teeth are moved via metal wires threaded through metal brackets attached to teeth. To attach the brackets it is typically necessary to etch the tooth with phosphoric acid, then apply a coupling agent (termed a primer) which enables an adhesive bond to form between the metal of the bracket and the hydroxyapatite of the tooth.
- While the procedures themselves are well established there are still problems associated with bonding the brackets onto the enamel surface,. Bracket failure remains a common problem, with about 6% failure (Millett *et al.*, 1998) which may result in the patient needing to return to the dentist to have the brackets re-attached. Ultimately this costs both the practitioner and the patient time and money with the English NHS spending over £4 million on bracket repairs (Dental Practice Board, 1997).
- The reason for these failures remains unclear. We propose that it is likely to be due to either:
  - poor spreading of the etchant of the tooth or
  - poor coupling between the metal and the hydroxyapatite.
- In this work the bond strength was measured of metal brackets attached to human premolars treated with commercially available acid-etchants (of a range of viscosities) and primers (either hydrophobic or hydrophilic).

Materials (1)

Etchant	pH	Constituents (%wt)
Scotchbond Liquid Etchant (SL) Low viscosity	1.0	30-40% H_3PO_4, 60-70% H_2O
Scotchbond Gel Etchant (SG) Medium viscosity	1.0	30-40% H_3PO_4, 5-15% poly(vinyl alcohol) 50-60% H_2O
Kerr Etchant (Kerr) High viscosity	1.0	37.5% H_3PO_4, 62.5% H_2O and fumed silica

SL and SG manufactured by 3M Unitek, USA.
Kerr manufactured by Sybron Dental Specialties, USA

Method

1. 3 etching agents (low, medium and high viscosity) and 2 primers (one hydrophobic and one hydrophilic) were selected.
2. 10 µL of each etchant was dispensed onto extracted human incisors (n=5 per etchant) and left for 15 s. Next the teeth were washed in copious distilled water and then prepared for SEM examination via fixing with glutaraldehyde, dehydration through an ethanol series and then gold coating.
3. 60 extracted human premolars (Hobson *et al.*, 2002) were divided into 6 groups representing each pair of etchant and primer. Each tooth was mounted in epoxy resin so that the lingual surface was proud of the surface. Teeth were etched and primed according to the manufacturer's instructions, and a stainless steel bracket was then bonded to the prepared tooth using an acrylic resin (Transbond XT, 3M Unitek, USA).
4. Bond strength was measured in tension by threading a stainless steel orthodontic wire through the bracket and then attaching this wire to a specially made holder in a universal test machine (Instron model 5567, Berks, UK). Tensile force (@ 1 mm/min) was applied until the bracket debonded from the tooth

Results

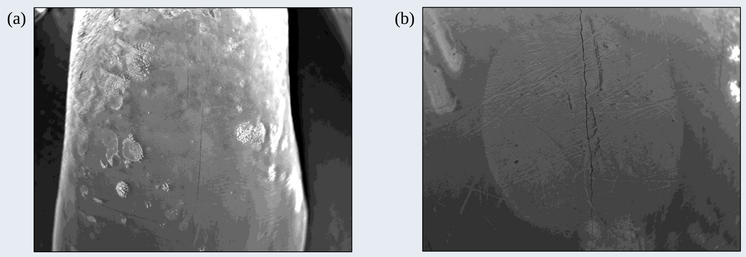

Figure 1: Typical SEM micrographs of an over-etched SL treated surface (a) and a more-defined Kerr treated surface (b)

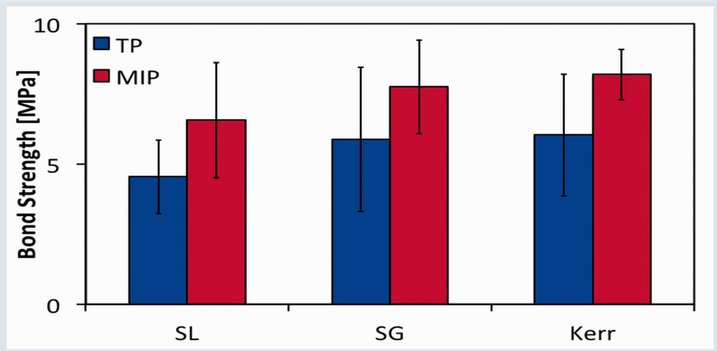

Figure 2: Relationship between mean tensile bond strength and choice of etchant and primer. Error bars represent 1 SD. N= 10 for each etchant and primer combination.

Materials (2)

Primer	Constituents (%wt)
Transbond Primer (TP) Hydrophobic	dimethacrylates: 20 – 30.5 quartz and silica: 70 - 80
Moisture Insensitive Primer (MIP) Hydrophilic	ethanol: 30 - 40 dimethacrylates: 15 - 35 2-hydroxyethyl methacrylate: 10 - 20 itaconic-co-acrylic acid: 5 - 15 2-hydroxy-1,3-dimethacryloxypropane: 5 - 15 H_2O: 1 – 10

TP and MIP manufactured by 3M Unitek, USA.

Discussion

- In general, the low viscosity etchant spread across the whole tooth surface, while the mid and high viscosity gels left defined areas of etched hydroxyapatite (figure 1). Over-etching of tooth can lead to weakening resulting in premature fracture[1], typical of the bond strengths found for SL specimens shown in figure 2.
- The Kerr treated teeth had the highest bond strengths for both primers.
- For each etchant the MIP treated teeth had significantly greater bond strengths ($P<0.05$ or lower, two-way ANOVA with Tukey's test) than the TP treated teeth.
- The addition of hydrophilic monomers to priming agents has been previously shown to improve bond strengths in restorative dentistry[1]. The present data suggest that this is also true in orthodontics.
- Within the limits of an *in vitro* study, these data suggest that the rate of premature bracket debonding may be reduced if a high viscosity etch is used with a hydrophilic priming agent to precondition the teeth.

Conclusion

- Both the viscosity of the acid etchant and the hydrophilicity of the primer have a significant effect on the bond strength of brackets to teeth
- The rate of premature bracket debonding would be significantly reduced if a viscous etch were used with a hydrophilic primer

References: 1: Van Meerbeek, B. *et al.* Operative Dentistry, 2003, 28-3, 215-235
2: Millett DT, Hallgren A, Cattanach D, McFadzean R, Pattison J, Robertson M, *et al.* (1998). A 5-year clinical review of bond failure with a light-cured resin adhesive. *Angle Orthod* 68:351-356.
3: Hobson RS, Rugg-Gunn AJ, Booth TA (2002). Acid-etch patterns on the buccal surface of human permanent teeth. *Arch Oral Biol* 47:407-412.
4: Fox NA, McCabe JF, Buckley JG (1994). A critique of bond strength testing in orthodontics. *Br J Orthod* 21:33-43.

* *BDS undergraduate*, Simon.Hobson@ncl.ac.uk