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Quantitative analysis of enamel on debonded orthodontic brackets

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Introduction: Iatrogenic damage to the tooth surface in the form of enamel tearouts can occur during removal of fixed orthodontic appliances. The aim of this study was to assess debonded metal and ceramic brackets attached with a variety of bonding materials to determine how frequently this type of damage occurs. **Methods:** Eighty-one patients close to finishing fixed orthodontic treatment were recruited. They had metal brackets bonded with composite resin and a 2-step etch-and-bond technique or ceramic brackets bonded with composite resin and a 2-step etch-and- bond technique, and composite resin with a self-etching primer or resin-modified glass ionomer cement. Debonded brackets were examined by backscattered scanning electron microscopy with energy dispersive x-ray spectroscopy to determine the presence and area of enamel on the base pad. **Results:** Of the 486 brackets collected, 26.1% exhibited enamel on the bonding material on the bracket base pad. The incidences of enamel tearouts for each group were metal brackets, 13.3%; ceramic brackets, 30.2%; composite resin with self-etching primer, 38.2%; and resin-modified glass ionomer cement, 21.2%. The percentage of the bracket base pad covered in enamel was highly variable, ranging from 0% to 46.1%. **Conclusions:** Enamel damage regularly occurred during the debonding process with the degree of damage being highly variable. Damage occurred more frequently when ceramic brackets were used (31.9%) compared with metal brackets (13.3%). Removal of ceramic brackets bonded with resin-modified glass ionomer cement resulted in less damage compared with the resin bonding systems. (Am J Orthod Dentofacial Orthop 2017;152:312-9)

The aim of bracket debonding is to remove appliances and any bonding material from the teeth, restoring the original esthetics and contours while minimizing iatrogenic enamel loss during the procedure.[1] Appliance and bracket removal does cause some damage to the tooth surface.[2] This can occur at bracket removal if the enamel fails cohesively, resulting in cracks[3] and tearouts,[4,5] or it can occur during removal of adhesive remnants.[6]

Many bonding materials and methods are available for the placement of orthodontic brackets. All of these have their own unique material properties that influence their mode of failure during orthodontic bracket removal.[7] It is estimated that bonded orthodontic brackets need a bond strength of 5.9 to 7.8 MPa to be retained.[8] Many bonding systems meet or exceed this requirement.[9] For example, metal brackets bonded to enamel with conventional 2-step etch and bond with Transbond XT composite resin (3M Unitek, Monrovia, Calif) had a reported bond strength of 20.2 MPa,[10] the strength of self-etching primer (SEP) with Transbond XT was 11.1 MPa,[11] and the strength of Fuji Ortho LC resin-modified glass ionomer cement (RMGIC) (GC Corporation, Tokyo, Japan) was 13.6 MPa.[10] Ceramic brackets may also have high bond strengths to enamel. Using a 2-step etch-and-bond technique, Heliosit composite resin had a reported bond strength of 24.25 MPa.[12] Therefore, in some situations, the bond strength of the adhesive to the enamel may be higher than the cohesive strength within the enamel, resulting in cracks or tearouts at debonding.[10,12,13]

Although enamel loss as tearouts during orthodontic bracket removal has frequently been reported in vitro, there are few clinical studies on this topic.[14] Using backscattered scanning electron microscopy,

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Boyde[5] reported that enamel tearouts were clearly observable on the bonding surfaces of clinically debonded ceramic orthodontic brackets attached with composite resin. However, the influence of bracket and adhesive type was not explored. A more recent, energy dispersive x-ray spectrometry evaluation of clinically debonded metal brackets attached with a 2-step etch-and-bond retained composite resin showed that as the amount of resin on the base pad increased, so did the amount of calcium (assumed to be enamel).[4] This study did not report the overall frequency of damage or examine the extent of damage when ceramic brackets were used. Therefore, more clinical investigation into the frequency and extent of this problem is warranted to ensure that bracket-adhesive combinations are selected to minimize iatrogenic enamel loss as tearouts during bracket removal.

The aim of this clinical study was to determine the extent and frequency of iatrogenic damage to enamel when debonding metal and ceramic orthodontic brackets attached by various bonding materials in vivo.

MATERIAL AND METHODS

Ethics approval for the study was obtained from the Human Research Ethics Committee (number 1136902) of the University of Melbourne in Australia. Patients close to finishing fixed orthodontic treatment were recruited from 5 private orthodontic practices. Practices were invited to participate if they met the following inclusion criteria: (1) the clinicians in the practice used either metal In-Ovation R brackets (GAC International, Bohemia, NY) or ceramic In-Ovation C brackets (GAC International); (2) they used 1 of the 3 following adhesive protocols: 37% phosphoric acid etch, Orthosolo bond (Ormco, Orange, Calif), and Transbond XT composite resin (3M Unitek); pumice with a cup, SEP (Transbond Plus Self Etching Primer, 3M Unitek), and Transbond XT composite resin; or pumice with a cup, Fuji Ortho Conditioner (10% polyacrylic acid), and RMGIC (Fuji Ortho LC encapsulated; GC Corporation); and (3) the clinicians needed to debond ceramic brackets using the sharp blades of the debonding pliers at the level of the base pad, placing a wedging force at the adhesive level, and debonding metal brackets using the debracketing instrument (444-761; 3M Unitek). This instrument has a wire hook that goes under a bracket wing and is stabilized against the adjacent enamel, enabling the bracket to be pulled off the adhesive and tooth in a safe and comfortable manner. It is a reproducible and standardized technique. The instrument cannot be used on ceramic brackets because of their brittleness.

Table I. Presence of enamel, percentage of bracket base covered with enamel, BARI score, and frequency of bracket fracture for the various bracket-bonding material combinations

	*Ceramic brackets**			*Metal brackets**
	CGIC† (*n* = 66‖)	*CSEP*‡ (*n* = 144‖)	*CEC*§ (*n* = 126‖)	*MEC*† (*n* = 150‖)
Presence of enamel				
No	80.3	61.8	69.8	86.7
Yes	19.7	38.2	30.2	13.3
Percentage of bracket base covered with enamel				
0%	80.3	61.8	69.8	86.7
>0%-<1%	15.2	16.7	12.7	8.7
1%-<5%	3.0	9.0	7.9	3.3
5%-<10%	1.5	5.6	4.0	1.0
≥10%	0.0	6.9	5.6	1.0
BARI				
Score 0	53.0	36.8	49.2	39.3
Score 1	37.9	29.9	30.2	49.3
Score 2	9.1	9.0	4.8	6.0
Score 3	0.0	11.8	5.6	2.7
Score 4	0.0	10.4	7.9	2.7
Score 5	0.0	2.1	2.4	0.0
Bracket fracture				
No	87.9	93.8	73.8	100.0
Yes	12.1	6.3	26.2	0.0

*Cell values are percentage of surfaces; †Orthodontist A treated 11 patients with CGIC and 25 patients with MEC; ‡Orthodontists B and C treated 15 and 9 patients with CSEP, respectively; §Orthodontists D and E treated 13 and 8 patients with CEC, respectively; ‖Number of surfaces: each patient contributed 6 surfaces.

Therefore, patients fell into 1 of the following 4 groups: MEC, metal bracket attached with Transbond XT composite resin bonded to the tooth with a 2-step etch-and-bond technique; CEC, ceramic bracket attached with Transbond XT composite resin bonded to the tooth with a 2-step etch-and-bond technique; CSEP, ceramic bracket attached with Transbond XT composite resin bonded to the tooth with SEP; or CGIC, ceramic bracket attached with RMGIC. The numbers of patients from each office are shown in Table I.

In total, 81 patients were recruited into this study. Brackets from the maxillary right to left canine were collected and sterilized by 4.1 kGy gamma irradiation. Of the 486 brackets collected, 49 fractured at removal, so only 437 brackets were visualized by backscattered scanning electron microscopy under 60 times magnification (low vacuum; no coating; backscatter mode; spot size 4; 15 kV; resolution 2048 × 1768; Quanta 200F scanning electron microscope; FEI, Hillsboro, Ore). An elemental map of calcium, phosphorus, aluminum, and silicon on the bracket base was also