Abstract of the thesis entitled "Hertzian indentation failure of dental restorative materials"
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Although many mechanical test methods have been used for evaluating the strength of dental materials, their relevance has seldom been considered in the context of actual service. Failure modes produced by most traditional tests are not consistent with clinical observations. The Hertzian indentation test appears to model well the oral mode of loading and resulting stress fields; however, so far it has only been used for ceramics.

The purposes of the present study were to explore the usage of Hertzian indentation testing for two relatively-brittle dental restorative materials: amalgam and glass ionomer cement (GIC). The effects of some geometrical and material variables: specimen thickness *(t)*, indenter radius *(R_i)*, and relative elastic moduli of substrate and coating *(E_s/E_c)* were investigated in order to identify the conditions under which the clinically-relevant failure would be reproduced. Coating-substrate bi-layer structures were tested for various *t*, R_i and E_s, covering wide ranges of values. The load at the first crack and the failure mode as observed by SEM were used for analysis. In addition, the influence of other test conditions such as storage medium (air, artificial saliva), specimen surface roughness, bonding and interfacial constraint were also studied.

The failure modes induced in amalgam and glass ionomer by Hertzian indentation were similar to those observed in ceramics and it was confirmed that clinically-relevant failure can be produced in these two materials by this test. The failure load increased steadily with *t*, E_s and R_i initially, but then levelled off. This change was attributed to the alteration of failure mode: with increase in the value of *t*, E_s and decrease of R_i, the principal failure mode tended to change from bottom-initiated radial cracking to top-initiated cone cracking or plastic deformation. There was an intermediate stage during the transition from the one to the other behaviour. Interaction was found between *t* and R_i for amalgam. Resin-modified GIC showed more plastic failure behaviour and higher failure loads than conventional GIC. Bonding of coating and substrate increased the failure load of thin amalgam coatings, however, applying lubricant on the coating-substrate interface decreased the failure load of GIC because of the reduced interfacial constraint. Compared with air, artificial saliva storage showed a negative effect on the development of the strength of amalgam and GIC.

It is concluded that the Hertzian indentation test is a practical, effective and clinically-relevant method for investigating the failure behaviour of dental restorative materials. *t*, R_i and E_s strongly control the failure load and mode of coating/substrate structure under Hertzian indentation. The failure behaviour and fracture resistance of GIC mainly depend on its type or setting mechanism. Any discussion of failure load or strength must be combined with consideration of failure mode. In addition, the effect of other test conditions, such as storage medium and boundary constraint, on the results should also be carefully taken into account. Because of its mimicry of oral loading, Hertzian indentation test can be taken as a routine for testing in the dental field.