Cracks in gold crowns cemented on amalgam restorations

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Odén A, Tullberg M. Cracks in gold crowns cemented on amalgam restorations. Acta Odontol Scand 1985;43:15–17. Oslo. ISSN 0001-6357.

Twenty-seven gold crowns, removed from patients with problems such as diffuse pain and metallic taste, have been examined. The gold crowns were made of an ordinary casting gold alloy, type III. The crowns were built on amalgam cores or big amalgam fillings. Eight of these crowns had cracks beginning at the cervical margin and propagating occlusally. The crowns were examined in a scanning electron microscope equipped with an energy-dispersive detector. The study showed that the cracks propagated along the grain boundaries within the gold alloy. In the cracks corrosion products usually found on amalgam were identified. The cracks could be due to intercrystalline stress corrosion or overloading. □ *Amalgam; corrosion; gold crowns*

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For many years in operative dentistry gold crowns have been cemented on amalgam cores or on prepared teeth with amalgam fillings. Increasing knowledge concerning the corrosion behavior of amalgam when in contact with gold alloys (1–3) has made this form of treatment less common.

The purpose of the present investigation was to report the clinical and metallographic findings made when examining a material of extracted teeth with gold crowns cemented on amalgam restorations.

Materials and methods

The material consisted of 27 gold crowns removed from patients with problems such as diffuse pain and metallic taste. The gold crowns were built on amalgam cores or on teeth with big amalgam fillings. Eight of the crowns had cracks, most of them visible to the eye, but some of them were too small to be visually detected. Suspicious areas, however, could be detected by the discoloration of the gold surface, which was seen to follow small cracks.

The crowns were examined in a scanning electron microscope (SEM) operating both in secondary and back-scattered electron mode. The type of gold alloy and the content in the cracks were identified with an energy-dispersive detector (EDS) attached to the microscope. To decide whether the cracks propagated along trans- or inter-crystalline paths, the crowns were also examined in SEM after being polished and etched in aqua regia.

Results

The range of compositions of the crowns is given in Table 1. The analyses indicate that the crowns were made of ordinary casting type III gold alloy. The grain size varied between 60 and 80 μm.

Table 1. Composition limits of gold alloys

Metal	Weight, %
Gold	72.8–78.0
Silver	3.4–6.9
Copper	13.2–17.4
Platinum	0–3.3
Zinc	0.8–1.5

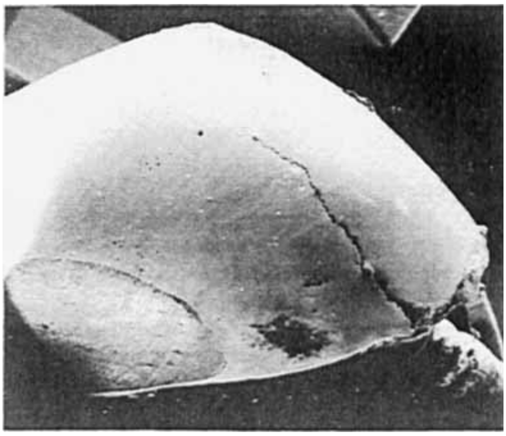

Fig. 1. Gold crown built on an amalgam core with a main crack going from the cervical border to the occlusal part of the crown.

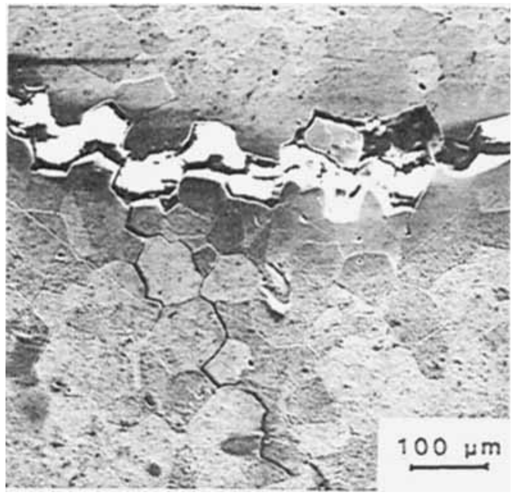

Fig. 3. A branched crack propagating along the grain boundaries. The gold surface is etched in aqua regia. Corrosion products from amalgam are seen in the main crack.

The cracks were oriented in a gingival/occusal direction (Fig. 1). Similar cracks were also found in gold crowns cemented on teeth with amalgam cores and on large mesial-occlusal-distal amalgam fillings and in gold crowns with amalgam restorations along their margins.

The cracks were observed to branch (Fig. 2), and after polishing and etching (Figs. 3 and 4) they could be seen to propagate along intercrystalline paths. In the main crack (Fig. 3) corrosion products containing P, Cl, Sn, and Zn were identified by EDS.

Discussion

The pattern of the cracks indicates that they could be due to intercrystalline stress corrosion (4). The stresses responsible for failure may in some cases be due to delayed expansion (5, 6) or expansion during cor-

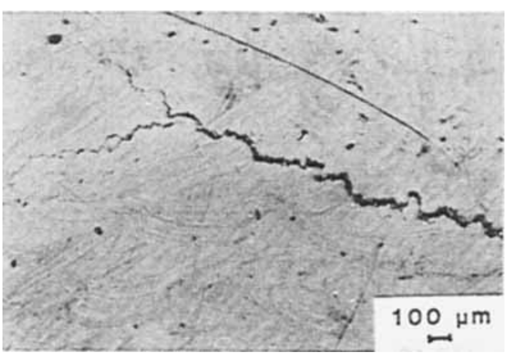

Fig. 2. The occlusal part of the crack in Fig. 1.

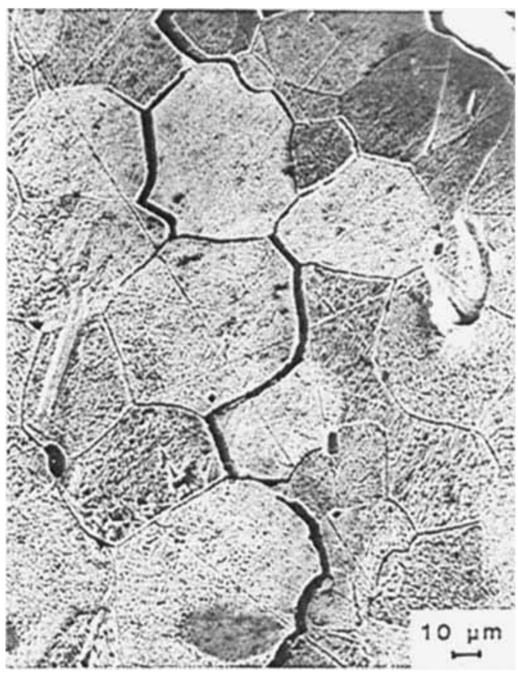

Fig. 4. A small branch of the crack shown in Fig. 3.

rosion of the amalgam core or filling (7). Nothing is known in this case about the age of the amalgam when the crowns were cemented. Usually, however, amalgam cores are made in connection with the gold crowns, and thus delayed expansion could cause stresses. Stresses could also be due to overloading. When a gold crown is cemented on an amalgam core or filling, the load can cause creep deformation of the amalgam alloy (8).

In stress corrosion cracking, mechanical failure and electrochemical dissolution occur simultaneously. In this case electrochemical dissolution of the grain boundaries in the gold crowns could be due to the presence of segregated alloying elements (9). Another explanation could be mercury diffusing into the grain boundaries in regions where there was contact between amalgam and gold (10). In this study corrosion products derived from amalgam were identified in the main cracks. Corrosion layer produced in amalgam during clinical use has earlier been reported to contain Sn, P, S, and Cl (11–13).

When the mercury-containing phases in amalgam corrode, excess mercury can diffuse into the amalgam or, if the amalgam is in contact with gold, into the grain boundaries of the gold alloy.

The small area of amalgam exposed to the oral cavity through cracks will give a small anode and a big cathode, and this will cause accelerated corrosion of the amalgam (4). This corrosion causes the release of metallic ions, which can cause problems for some individuals. In this case the gold crowns were obtained from patients with symptoms such as a metallic taste from the teeth before extraction.

It is not known how common cracks in gold crowns are, but we believe that many cracks have not been detected simply because no one has looked for them. Our study shows that cracks in gold crowns built on amalgam restorations do occur when made from ordinary casting type III gold alloy.

Received for publication 19 January 1984

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