Screening Test for Metal Identification in Prosthetic Dentistry

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Screening Test for Metal Identification in Prosthetic Dentistry

Author(s): Lucien R, Luethy H, Eschler P, Blatter A, Schmidli F

Abstract

* The identification of the chemical nature of metallic restorations may provide useful information in odontological diagnosis.
* Dentists commonly use the splint-test for such identification. Abrasion debris is collected from the metal restoration in the patient’s mouth, and the sample is then sent to a laboratory for chemical analysis.
* This paper describes a simple technique of qualitative analysis, allowing the practitioner to rapidly identify the dental alloy on the spot.

Introduction

In practice, the dentist sometimes meets the problem of lacking information concerning the prostheses in the patient’s mouth. In particular, the practitioner may be confronted to metallic constructions of unknown composition. In certain clinical cases however, knowing the composition is requisite for future treatment.

At the School of Dentistry of the University of Basel, to give an example, the composition of dental alloys is routinely analyzed employing energy-dispersive x-ray analysis (EDX) in an electron microscope.1 The alloy samples are taken by the dentist directly from the mouth of the patient.

The drawback of this method of elemental analysis is that it needs sophisticated and costly equipment as well as qualified operators. Practitioners therefore have to send their samples to specialized laboratories, implying a more or less important delay.

Modern instrumental techniques like inductively coupled optical or mass spectrometry, chromatography and electrochemistry have spectacularly advanced analytical chemistry. Despite this sophistication, or perhaps precisely because of it, there is a growing need for simple and cheap test methods enabling rapid, semi-quantitative identification of certain elements or chemical compounds. These methods rely on a variety of techniques, ranging from elementary precipitation of a coloured compound to sophisticated immunological assays with antibodies (EISA, ELISA, MELISA, LTT-CITA,..). Rapid testing are routinely carried out with success in many different fields such as in clinical analysis, forensic science, contact allergies, comestible goods or environmental analysis.

The metals used in dental prosthetic dentistry show a wide variety. Dental Vademekum 2 alone enumerates about 800 dental alloys available on the German market. The classification of dental alloys is complex task, subject to considerable modifications for reasons of economy and biocompatibility3.

In practice, the most basic information a dentist wishes to know concerns the nature of the metallic prosthesis, whether it is made from a precious or non-precious alloy. In case of precious metals, the question arises whether it contains gold, platinum or palladium. In the other case the question is whether it is made of a nickel-chromium (NiCr) or a cobalt-chromium (CoCr) alloy.

Methods

A. Metal identification using the splint-test

The splint-test consists in two steps; sample taking and EDX analysis.1,3,4 A powdery sample is taken by abrasion of the metallic prosthesis in the patient’s mouth as illustrated in fig. 1. The metal debris are then collected (Fig.2) and sent to a laboratory equipped with an electron microscope for the analysis of the chemical composition of the clinically used alloys. The splint-test has been routinely and successfully employed by one of the authors (F. Schmidli) for over 15 years.

B. Metal identification using rapid field tests

In this approach of rapid testing, a powdery sample is taken in the very same way as in the splint-test. Instead of sending the sample to the laboratory for EDX-analysis, however, the metal identification is carried out on the spot using specific chemical reactions.

To do so, the collected metal debris first has to be dissolved. For the dissolution, the sample is placed in a test tube (of a volume of about 5 mL). When adding about 1 mL (5 drops) of hydrochloric acid solution (concentration 4M), the debris will dissolve within approximately 15 minutes.

The use of specific analytical reactants, each with a high selectivity for either nickel, cobalt, iron or copper
(fig. 3), then allow the discrimination between non-precious (NiCr, CoCr) and precious metal alloys.

**Nickel test**

Dimethylglyoxime and rubeanic acid tests are employed for the detection of the presence of nickel. The two reactants are well known and have been used for a long time in analytical chemistry. In particular, they are used for the rapid nickel testing of products intended to come into direct and prolonged contact with the skin according to European Directives on Nickel.

For the present case, a micro haematocrit tube (Brand GMBH, ISO 12772) is used to take 3 micro litres of the sample solution and to drop them on an analytical test strip from the “MERCK Nickel Test” (Merckoquant®, art. 1.10006.0001). A further drop of ammoniac of concentration 10% is added. A red coloration of the strip indicates the presence of nickel (Fig. 4).

Now dimethylglyoxime also forms colored complexes with the cations of Fe2+ (red), Pd2+ (orange) and Pt4+ (yellow). Therefore, a second test with rubeanic (dithio-oxamide) acid is necessary in order to avoid any misinterpretation. Again, drop 3 micro litres of the sample solution on an analytical strip and add this time a drop of saturated ammonium acetate. A dark blue color confirms the presence of nickel since rubeanic acid does not form colored complexes with neither iron nor palladium nor platinum. In consequence, the dental metal is a NiCr alloy if both tests respond with the specific colors.

Note that Vademekum does not list any precious metal alloy containing nickel, chromium or cobalt.

Given that the later generations of NiCr alloys often contain significant amounts of iron, the detection of this element might be useful.

**Iron test**

Three micro litres of the sample solution are dropped on an analytical test strip from the “MERCK Iron Test” (Merckoquant® 1.10004.0001). A red colour of the complex formed after the addition of a drop of ammoniac (concentration 10%) indicates the presence of iron. If both the nickel and iron tests were positive, the metal is identified as a NiCrFe alloy.

**Cobalt test**

Three micro litres of the sample solution are dropped on a specific analytical test strip from MERCK (Merckoquant® 1.10002. 0001). A green colour indicates the presence of cobalt and the metal is identified as a CoCr alloy.

It is worth to note that the identification of chromium is more complicated. Dissolved chromium exists in two oxidation states; Cr+3 et Cr+4. The dissolution of a chromium alloy in hydrochloric acid produces Cr+3, for which no selective indicator exists in analytical chemistry.

**Copper test**

Three micro litres of the sample solution are dropped on a specific analytical test strip from MERCK (Merckoquant® 1.10003.0001). A violet colouration indicates the presence of copper.

If nickel is detected together with copper, then the metal is identified as a copper base alloy of the type NPG, Gaudent, Trindium, Orden, Goldent etc.

If only copper but no nickel is detected, the alloy is most probably a precious metal containing copper. A further test would then be necessary to confirm the precious nature by testing for gold or platinum.

**Gold and platinum test**

The presence of either gold or platinum can be tested by use of stannous chloride. With gold, stannous chloride forms the purple of Cassius, a blood-red complex. Platinum ions form a similar, blazing red complex.

**Results and Discussion**

The rapid test methods were applied to seven different dental alloys. Table I lists the nominal compositions of the test alloys. Table II displays the results of the rapid testing of these alloys together with their identification.

**Conclusion(s)**

The presented tests do not aim at the precise determination of the alloy composition, but rather at providing a method for the rapid discrimination between common dental alloys (CoCr, NiCr, Cu based and precious metals) at a reasonable price. The procedure is simple and does not need any particular expertise; any practitioner can apply it without special training. There is no toxicological risk neither for the patient nor for the practitioner carrying out the tests. The test sample can be taken “in-vivo”, no need to damage the prosthetic component or to take it out of the oral cavity. The tests are conceived for the dentist’s practice and the necessary reactants are easily available from suppliers of chemical products.

**Reference(s)**


5. CEN REPORT (CR) 12471 Screening tests for nickel release from alloys and coatings in items that come into direct and prolonged contact with the skin


Table 1

<table>
<thead>
<tr>
<th>Code</th>
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Nominal compositions (wt.%) of selected test alloys.
Illustration 2

Table 2

Positive (+) and negative (-) responses of the test alloys in the rapid nickel, cobalt, copper and iron tests and the corresponding alloy identification. 1) nickel test using dimethylglloxyme; 2) nickel test using rubeanic acid.

<table>
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<th>Code</th>
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<th>Ni₂</th>
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<th>Cu</th>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>Precious metal</td>
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</tbody>
</table>
Illustration 3

Fig. 1 Sample taking in the mouth. The dentist abrades the metallic prosthesis (left) by means of a rotative instrument (centre). The rotation projects the fine debris to the right where it is collected on a sticking, graphitized sample holder.
Illustration 4

Fig.2 Zoom onto the surface of a sample holder showing the collected metal debris (bright spots) to be analyzed
Illustration 5

Fig.3 Analytical test strips (Merck) for, from left to right : iron, nickel cobalt and copper
Illustration 6

Fig. 4 Example of a positive response from a nickel test.
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