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# Long-term Clinical Evaluation of Fixed Dentures – Two to Fifteen Years after Insertion

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**Abstract:** Fixed denture durability is characterized as a period of time for which a dental appliance satisfies functional and esthetic requirements. First of all, its durability is based on the properties of materials it is made of, and depends, at the same time, on the characteristics of biological environment, in which the denture is placed. The purpose of this study was a long-term monitoring of changes taking place in the fixed dental constructions during their application in the oral cavity. These changes were to be evaluated for different types of materials used for fixed dentures manufacturing, namely metal alloys, ceramics, and plastics. A set of 454 full crowns from 134 patients divided in 6 clinical studies was examined and both qualitative and quantitative changes evaluated after 2 and 8 to 15 years after cementation. Clinical assessment adopted the United States Public Health Service System criteria. Alloys of precious metals veneered with ceramics are considered the optimal method of choice for both high precision of execution and consideration of future changes brought on by the use of the dentures.

**Key words:** Fixed denture – Dental alloys – Dental plastics – Ceramics – Oral hygiene.

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**Introduction**

Fixed dentures belong to basic devices used for rehabilitation of the function of the whole orofacial system. They become a long-term component of a biological system and thus their quality may positively or negatively influence different parts of the human organism. In the oral cavity newly incorporated fixed dentures are characterized by specific mechanical, physical, chemical, biological and esthetic properties. These characteristics frequently change in the aggressive oral environment. Material wear and degradation with following quantitative and qualitative changes appear on the whole fixed denture (Fig. 1, 2). Therefore concerning material, these changes limit the fixed dental construction durability. A worn-out or defective fixed denture doesn't function properly or may affect the dental system structures negatively.

For this reason, the fixture durability ensues primarily from the properties of the material of which it is made. Secondarily it depends on biological properties of the environment to which it is permanently included [1]. Factors influencing durability can be summed up as follows: indication of denture type and material used, respect of technology, lege artis work at chairside, oral cavity environment (pH, temperature), microbial flora, hygienic and eating habits, anatomic and inter-jaw relations, neuromuscular activity, biological dental factor.

Complete dentition is important for optimal function of the whole alimentary system and in broader relations of the organism as a single unit. The loss of one tooth or more of them breaks the integrity of the dental arch. This may have negative consequences not only for the quality of basic dental functions – mastication, phonation and esthetics, but also for residuary teeth and their periodontal tissues, alveolar bone and related anatomic structures, e.g. masticatory muscles and temporomandibular joints [2]. As long as individual parts of the system "teeth – bone – muscles – joint" are able to adapt to the new situation, the function is not greatly disturbed. A subsequent weakening or disorder of one of

*Figure 1 – Marked abrasion of plastic veneer on tooth 13 after 14 years of functioning.*

*Figure 2 – Complete wear of veneered crown 23 made of golden alloy after 14 years.*

the parts may result in decompensation in a system with clinical manifestations [3].

The objective of fixed dentures application is not only prosthetic rehabilitation and its good prognosis, but also complex dental sanation, which would support the success of dental constructions and at the same time guarantee a long-term prospective optimal function of the whole orofacial system [4].

First of all, dental construction durability is based on the selection of proper materials of which they are made. It is all about longevity (quality) of metals and their alloys, plastics and ceramics. Each of those dental materials has its characteristic properties. Modern dentistry is focused especially on mechanical resistibility, esthetic properties and biological tolerance – biocompatibility. It is defined as the capability of material to produce appropriate biological response while applied in the organism [5]. The reaction of material to mechanical loading, to changes of temperature or pH of the surroundings, to the effect of biological liquids may weaken its biocompatibility and thus its acceptable application life in the oral cavity. From this point of view the quality of denture surface adaptation is very important. Rough surface usually allows high plaque accumulation. Plaque microorganisms' products contribute to the general material degradation. Rough surface is larger than polished which permits greater amount of particles to separate into saliva. The mentioned processes are closely related to the possible immune response of the organism and problems of metal allergy, namely nickel, chromium and palladium. Prosthetic plastics hypersensitivity is connected with the amount of unpolymerized material leached particles – acrylate and diacrylate monomer [6]. Dental ceramics is resistant to corrosion and biologically best accepted from the mentioned main types of prosthetic materials.

Denture surface stability depends above all on laboratory processing and then on eating and hygienic habits of each individual. The basic condition of long-term surface stability is perfect polishing of metal and plastic dentures' parts and immaculate ceramic glaze. Even an initially perfect smooth surface is gradually wearing because of mastication. Incorrect oral hygiene and parafunctions contribute to these changes.

Modern specialized literature treating the dentures' durability from a complex standpoint is not ample. We usually come across professional reports, which describe and evaluate in detail single aspects of durability. Some retrospective studies of classic crowns [7, 8, 9, 10, 11, 12] and reports describing clinical experience with different types of ceramic systems [13, 14, 15, 16, 17] are valuable contributions because of their complex approach to the problems of durability of these constructions.

**Objective of the study**

The objective of this study was long-term clinical monitoring of changes, which took place on fixed dentures during their function in the human oral cavity. Our task was to measure these changes and to evaluate them for certain types of

materials used for manufacturing fixed dental constructions: dental alloys, ceramics and plastics.

We observed the changes in function during the interval of one week up to 15 years using a set of 454 metal crowns veneered with C+B and composite plastics and ceramics.

Objective evaluation of dentures referred to: crown integrity, anatomic shape, material abrasion, occlusion, crown margin location, quality of marginal fit, caries presence, marginal gingival health and color stability.

**Materials and methods**

Full crowns made of metal alloys veneered with plastics or ceramics were chosen for fixed dentures evaluation. Our study included 454 crowns divided into 2 groups, namely one for clinical evaluation of crowns functioning two years, the other for crowns 8 to 15 years after cementation.

*The two-year clinical study of fixed appliances*

For the quality evaluation of artificial crowns after two-year function, 4 groups of patients were set up, two for the retrospective and two for the prospective studies according to the type of used crown material.

- 1st group – evaluation of crowns made of precious alloys and chromium, cobalt, nickel alloys with plastic veneers (retrospective study)
  A set of 50 crowns in 15 patients was established, with the crowns made of precious dental alloys (Aurix / Safina) and non-precious alloys (Wiron / Bego) with veneers from plastics (Superpont K + B / Dental) and composite plastic material (Sinfony / Espe).
- 2nd group – evaluation of crowns made of precious alloys with ceramic veneers (prospective study)
  This set consisted of 20 patients with 39 crowns made of 2 ceramic materials (Vita Omega, Vita Omega 900 / Vita) and two alloys suitable for ceramic fusing (Ag – Pd alloy Safibond, Au – Pt alloy Safibond Plus / Safina).
- 3rd group – evaluation of crowns made of chromium-cobalt alloy veneered with ceramics (retrospective study)
  Evaluated were 52 crowns in 19 patients. The crowns were made of chromium-cobalt alloy Wiron / Bego and ceramics Vita Omega / Vita.
- 4th group – evaluation of crowns made of precious metal alloy and chromium-cobalt alloy veneered with plastics and ceramics (prospective study)
  The total number of crowns made for 34 patients was 102 of which 54 crowns were cast from alloy Wiron / Bego and veneered with ceramics Vita Omega / Vita, 19 crowns were manufactured from low gold content alloy Aurix / Safina, 29 crowns were made of nickel alloy Wiron / Bego. Composites Sinfony / Espe and Evicrol / Dental were used as veneer materials.

The two-year studies were same in the following points: the groups of patients were made up by chance and according to the type of fixed construction and material. Patients were treated and controlled in by private dentists. They were always informed about their inclusion in a clinical study. Clinical groups were formed with the consent of the Ethics Committee of the First Faculty of Medicine, Charles University in Prague. A questionnaire was filled with each patient including the following information: name, identification number, health state, construction type. Teeth were prepared lege artis to the cone shape, preparation margins were placed slightly subgingivally or at gingival level. We modeled a rounded shoulder. The impressions were made with silicone C (Stomaflex / Dental), in the 2nd group we used silicone A (Aquasil / Dentsply Detrey). All abutment teeth were treated with provisional protective crowns. One attending doctor was always present. Veneered crowns were manufactured in 3 dental laboratories using common techniques. Crowns were cemented with zinc phosphate cement Adhesor / Dental.

One week and two years after cementation the crowns were studied, photographed (Dental Eye / Yashica, Japan) and impressed with silicone A. In laboratory were made oral cavity situation models that were evaluated in electronic raster microscope Jeol 5500 LV / Jeol, Japan. Anatomic shape, occlusal state, vestibular and oral surface of the crown and location of the crown margin were monitored. Changes in location of crown margins cannot be measured in electronic raster microscope and therefore we used comparison with a standard model Ivoclar – Williams / Ivoclar. In group 4 laboratory models were not used.

Clinical evaluation was carried out according to criteria of the United States Public Health Service System (USPHS). The following characteristics were monitored:

1. Relation to vestibular gingiva
2. Relation to oral gingiva
3. Gingival health assessed vestibularly and orally
4. Integrity of restoration
5. Secondary caries
6. Marginal adaptation
7. Evaluation of vestibular and oral crown margins
8. Color match

All patients were repeatedly instructed about proper oral hygiene.

*Clinical study of fixed dentures 8-15 years after cementation*

The state of crowns, which were functional for a time of 8-15 years, was evaluated on two patients' groups.

- 1st group – evaluation of metal crowns veneered with plastics (retrospective study)
  102 veneered crowns in 20 patients were checked. 52 crowns were made of precious metal alloy Aurix / Safina, 29 – of silver-palladium alloy Palargen / Safina and 21 crowns – of chromium-cobalt-nickel alloy Wiron / Bego. Veneer materials Superpont K + B / Dental in 94 crowns and composite plastics Visiogem / Espe were used.
- 2nd group – evaluation of crowns manufactured from chromium-cobalt alloy veneered with ceramics (retrospective study)
  Checked were 109 metal-ceramic crowns in 26 patients in the interval 8–15 years after cementation. Crowns were manufactured of alloy Wiron / Bego and veneered with ceramics Vita Omega / Vita.

The methods of examination and treatment were the same as those used in the two-year crown study.

*Figure 3 – Abrasion of ceramics after 15 years and intact metal construction on teeth 35 and 36.*

*Figure 4 – A crack in ceramic layer on tooth 32 (15 years of functioning).*

*Figure 5 – "Short crown" 15 years after cementation with exposing of cervical part of tooth.*

*Figure 6 – Comparison of veneer quality – crown 14 veneered with plastics (14 years) and crown 15 veneered with ceramics (13 years after cementation).*

**Table – Comparison of results of 8 up to 15-year retrospective studies**

| Relation to vestibular gingiva (¤, K, P) | | | | | | |
|---|---|---|---|---|---|---|
| | At gingival margin | | Above gingival margin | | Below gingival margin | |
| | C | P | C | P | C | P |
| Number | 30 | 30 | 38 | 54 | 40 | 16 |
| % | 28 | 30 | 35 | 54 | 37 | 16 |

| Relation to oral gingiva (P) | | | | | | |
|---|---|---|---|---|---|---|
| | At gingival margin | | Above gingival margin | | Below gingival margin | |
| | C | P | C | P | C | P |
| Number | 28 | 26 | 16 | 17 | 64 | 57 |
| % | 26 | 26 | 15 | 17 | 59 | 57 |

| Gingival health assessed vestibularly and orally (P) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Optimum | | Visible inflammation | | Bleeding on probing | | Metallic spot | |
| | C | P | C | P | C | P | C | P |
| Number | 59 | 31 | 46 | 42 | 3 | 27 | 6 | 5 |
| % | 55 | 31 | 42 | 42 | 3 | 27 | 7 | 5 |

| Integrity of restoration (C, P) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Intact | | Crack visible on | | Fracture present | | Crown lost | |
| | C | P | C | P | C | P | C | P |
| Number | 77 | 60 | 31 | 39 | 0 | 1 | 1 | 2 |
| % | 71 | 59 | 28 | 38 | 0 | 1 | 1 | 2 |

| Secondary caries | | | | |
|---|---|---|---|---|
| | Not visible | | Caries evident | |
| | C | P | C | P |
| Number | 106 | 97 | 2 | 3 |
| % | 98 | 97 | 2 | 3 |

| Marginal adaptation (¤, P) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Explorer does not catch | | Explorer catches | | Crevice at margin | | Obvious crevice | |
| | C | P | C | P | C | P | C | P |
| Number | 91 | 30 | 17 | 70 | 0 | 0 | 0 | 0 |
| % | 84 | 30 | 16 | 70 | 0 | 0 | 0 | 0 |

| Graded for vestibular and oral margins (¤, P) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | No discoloration | | Slight staining | | Obvious staining | | Gross staining | |
| | C | P | C | P | C | P | C | P |
| Number | 101 | 27 | 7 | 26 | 0 | 37 | 0 | 10 |
| % | 94 | 27 | 6 | 26 | 0 | 37 | 0 | 10 |

The obtained data were summarized and evaluated statistically using Fisher exact test ($P < 0.05$). Correlated differences between both veneering materials (ceramics and plastics) were calculated and significant distinctions between initial and follow-up results were assessed.

**Results**

The result of basic studies comparing qualities of both types of veneer materials in combination with precious and non-precious metal alloys including statistic evaluation of data, is shown in the table.

The results of all groups, in total consisting of 454 crowns, revealed the following:

1. Dental materials of the best mechanical and biological properties have basic influence on the durability of fixed prostheses.
2. Cast metal framework is resistant in a long-term service (Fig. 3).
3. Prosthetic polymers undergo degradation after two years of function and this process is permanent during the whole service life.
4. Ceramics is stable in its form and color shade but it is sensitive to fractures (Fig. 4).
5. Gingival health does not depend on the material used, but it derives from the patient's dental care.
6. Lege artis tooth preparation preserves vitality of the pulp.
7. The so-called "short crown" is of minimal importance in the presence of secondary dental caries (Fig. 5).

**Discussion**

Clinical studies compared the quality of both types of veneered crowns after more years of functioning. Despite the fact that most of the crowns remained functional, statistically important differences were found in some aspects of the evaluation. It primarily concerns the change of vestibular and oral crown margin, gingival state, margin precise adaptation and composite veneer color change (Fig. 6).

Precise adaptation of the crown margin tested by "checking by probing" is an aspect to be discussed, especially at subgingival preparation with absence of visual

**Table (continued)**

| | Color match (¤, C, P) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Good color match | | Slight mismatch | | Obvious mismatch | | Gross mismatch | |
| | C | P | C | P | C | P | C | P |
| Number | 94 | 31 | 11 | 25 | 3 | 37 | 0 | 7 |
| % | 87 | 31 | 10 | 25 | 3 | 37 | 0 | 7 |

C – metal crown veneered with ceramics, P – metal crown veneered with plastics, ¤ – significant difference between both materials, Fischer exact test ($P < 0,05$), C – significant difference between baseline and follow-up results (material C), P – significant difference between baseline and follow-up results (material P)

control. As we pointed out there may be several reasons for exposing the cervical part: wrong method of tooth brushing with predominant horizontal motions, prolongation of clinical crown due to teeth abrasion or atrophy of marginal gingiva as a result of mechanical irritation of periodontal tissues.

Walton [10, 11] in his ten-year study of metal-ceramic crowns and Erpenstein [19] in his fifteen-year observation of fixed dentures made of C+B materials prove that 83% of ceramics and 84% of dentures with veneered plastics remain operational with visual differences between two types of materials. A long-term clinical stability of metal-ceramic crowns [9, 10, 11] is based on strong metal-ceramic bond, and also on glassy and impermeable surface. Color stability of material is excellent and perfectly constructed margins don't irritate the periodontium. Proximal contacts of examined crowns remained preserved. One-year and two-year study of full-ceramic crowns showed that only 92% to 95% dentures remained intact [8, 13, 15].

Differing results were obtained in dentures veneered with plastics. In this study only 10% of crowns preserved initial esthetic quality. Moderate coloration of dental margins, transparency loss, reduced translucence and full veneer discoloration were seen. According to CRA clinical observation, full degradation of plastic veneer appears after 4 years. In his in vitro study Lakatos [20] writes that construction made of base metals due to corrosion may lead to damage of the connection with the veneer, and so influence the durability of the whole denture. Our study confirms that transparency changes take place in crowns made of base metals easier.

It is astonishing that any significant distinctions between two types of materials concerning the gingiva and precision of marginal fit were found. Burke [13] drew the same conclusion in his one-year study of metal-ceramic crowns. The results primarily depend on precise laboratory manufacturing and lege artis sequence of treatment steps. Type of veneered material influences slightly the health state of periodontium.

Caries is mentioned frequently as a major cause of dental construction failure. In our study caries presence had no statistical importance.

From the viewpoint of long-term durability only ceramics as a veneering material complies with strict functional criteria.

**Conclusion**

Results of clinical study may be summarized in a few conclusions.

1. Crown and bridge materials based on polymers are stable reconstructive materials for fixed dentures. The shortcomings are open-ended surface layers and a chance of penetration of degrading components from the surrounding area. We proved that this property becomes negatively apparent in veneer coloration, eventually loss of material transparency over the range of 2 years from manufacturing.

2. Clinical studies of metal-ceramic crowns show the high quality of materials used. On the basis of objective examinations it was found that glaze perfectly covers denture surface, sintering provides strong connection with metal alloys. Microscopic wear of denture in occlusal surface and marginal fit, which depends on the physiological process of mastication, is noticeable. So crown emplacement changes in the dental arch.
3. Precious metal alloys veneered with ceramics are objectively the optimal method of choice with the highest accuracy of execution and following changes during operation.
4. Fixed dentures made of ceramics fused to nickel alloy in comparison with constructions made of precious alloys show worse mechanical resistance – cracks were present in the ceramic layer. The basic finding is higher inaccuracy in marginal adaptation of crowns.
5. If veneers made of plastics and ceramics are to be compared, significant differences in esthetic quality of both materials were proved. Ceramics fully preserves its shape, size and volume, its color does not change. In plastics more than 90 % of veneers discolor and abrasion causes shape deformation.
6. The basic finding is that the crown type does not influence the gingival status.

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