A 2-year follow-up study of titanium crowns

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In 1986, 149 patients were provided with titanium crowns. The method used for fabrication of the titanium copings involved two principles: machine duplication of models and electric discharge machining. For the veneering of the copings, Isosit was used for the first 90% of the crowns in the series, and the Dentacolor-Silicoater technique for the last 10%. Of 205 individual crowns cemented in 1986, 167 could be examined after 2 years. The crowns were rated by four independent examiners using the CDA quality evaluation system. Bleeding Index and Margin Index were also used. The Margin Integrity score was recorded as satisfactory for all crowns examined over the period studied. A vast majority of the margins were rated as excellent. Isosit ($n = 145$) disclosed shortcomings including fractures and substantial deteriorations of Surface and Color and of Anatomic Form. With Dentacolor as veneering material ($n = 18$) the results with the factors Surface and Color and Anatomic Form were still rated satisfactory after 2 years, and no fractures of the veneering material were registered. Bleeding Index and Margin Index showed comparatively small changes after 2 years. □ *Clinical behavior; dental materials; fixed restorations; spark erosion; titanium*

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As a result of the rising price of gold there has been an increasing interest in finding suitable substitutes for high-gold alloys for crowns and bridges. One of these substitutes is titanium. Unalloyed titanium is exceptionally well tolerated in biologic environments, where it has a high corrosion resistance (1). Titanium is a cheap metal and has been used for a long time in dental implants—for example, in the successful long-term treatment with the Brånemark implants (2). However, as titanium is not easily precision cast, other fabrication methods have been developed for use of this metal within fixed prosthodontics. In a previous paper a combined technique for fabricating titanium crowns was described (3). The technique involves both machine duplication of models and electric discharge machining. With this technique the inherent error sources from waxing, investment, and casting procedures, associated with conventional methods, are eliminated.

In the previous report (3), in which the crown fabrication method was presented and discussed, preliminary clinical data were also presented. The aim of the present study was to report on the clinical results after 2 years with regard to these factors.

Materials and methods

In 1986, 205 individual titanium crowns were constructed in 149 patients. For details with regard to the fabrication of the titanium crowns, see the article by Andersson et al. (3). The first 90% of the crowns were veneered with Isosit® and the other 10% were veneered with Dentacolor® by the Silicoater® technique.

After 2 years the patients were recalled, and 124 of them attended the clinical reexamination. One of the non-attenders had a crown with Dentacolor as veneering material. The reasons for not attending were recorded as: two, deceased; five, ill; two, moved away; four, on long vacation; three, lack of time; one, therapy changed to fixed partial denture; seven, reported high satisfaction by telephone (could not attend); and one, did not respond.

The 124 patients had been provided with 177 crowns. However, from the initial exam-

Table 1. Evaluation of the characteristic Surface and Color in accordance with the CDA system (5) for the 167 titanium crowns that could be examined both in 1986 (= zero) and in 1988 (= 2 years). The results from 1987 (= 1 year) are based on 166 crowns

	Zero		1 year		2 years	
Satisfactory						
Excellent	141	98.2%	119	100%	98	90.4%
Acceptable	23		47		53	
Not acceptable						
Replace or correct	3*	1.8%	—	—	2	9.6%
Replace statim	—		—		14	

* Three Isosit facings had to be repaired at time 0.

Table 2. Evaluation of the characteristic Anatomic Form in accordance with the CDA system (5) for the 167 titanium crowns that could be examined both in 1986 (= zero) and in 1988 (= 2 years). The results from 1987 (= 1 year) are based on 166 crowns

	Zero		1 year		2 years	
Satisfactory						
Excellent	107	100%	103	98.8%	103	93.4%
Acceptable	60		61		53	
Not acceptable						
Replace or correct	—	—	—	1.2%	9	6.6%
Replace statim	—		2		2	

ination 10 of the crowns—5 up to the 1-year control and 5 up to the 2-year control—had been replaced because of extensive fractures of the veneering material Isosit. Of the remaining 167 crowns, 66 had been placed on front teeth, 77 on premolar teeth, and 24 on molar teeth. There were 112 crowns in the upper jaw and 55 in the lower jaw.

The crowns were examined by four licensed specialists in prosthetic dentistry who had undergone calibration with regard to the evaluation methods used (4). The following three characteristics were evaluated in accordance with 'Quality Evaluation for Dental Care' issued by the California Dental Association (CDA) (5): Surface and Color, Anatomic Form, and Margin Integrity. Furthermore, Bleeding Index (6) and Margin Index (7) were used. When the Bleeding Index was used, a contralateral tooth or a tooth close to the contralateral one was chosen as control.

Further details about materials and methods are provided in the previous report (3).

Results

No crown had come loose from the abutment tooth during the 2-year period.

CDA ratings

Owing to fractures of the composite resin Isosit, 10 out of 177 crowns had been replaced during the 2-year follow-up period among the 124 patients who attended the examination after 2 years. One patient wearing a crown with Dentacolor as veneering material could not attend the 1-year control. Consequently, the results at 0 and after 2 years are based on 167 crowns and those at 1 year on 166 crowns.

As to Surface and Color there was a slight decrease during the 2-year period for the rating satisfactory (Table 1). Furthermore, there was a change within the rating satisfactory from excellent to acceptable. A similar trend was seen with the factor Anatomic Form (Table 2). The changes occurred mainly between the 1- and 2-year controls.

With regard to the factor Margin Integrity (Table 3) all crowns were recorded as satisfactory from zero until the 2-year control. Only some minor changes from excellent to acceptable were found. This implies that no caries contiguous with the margins of the crowns had developed.

Table 3. Evaluation of the characteristic Margin Integrity in accordance with the CDA system (5) for the 167 titanium crowns that could be examined both in 1986 (= zero) and in 1988 (= 2 years). The results from 1987 (= 1 year) are based on 166 crowns

	Zero		1 year		2 years	
Satisfactory						
Excellent	149	100%	144	100%	144	100%
Acceptable	18		22		23	

Table 4. Evaluation of the characteristics Surface and Color, Anatomic Form, and Margin Integrity in accordance with the CDA ratings (5) for the 18 titanium crowns veneered with the Dentacolor-Silicoater technique which could be examined both in 1986 (= 0) and in 1988 (= 2 years). The results from 1987 (= 1 year) are based on 17 crowns

		Zero	1 year	2 years
Surface and color				
Satisfactory	Excellent	17	15	14
	Acceptable	1	2	4
Anatomic form				
Satisfactory	Excellent	15	13	15
	Acceptable	3	4	3
Margin integrity				
Satisfactory	Excellent	16	15	18
	Acceptable	2	2	—

Table 5. Bleeding Index in percentage recorded in accordance with Lenox & Kopczyk (6) for the 167 teeth with titanium crowns (T) and control teeth (C) which could be examined both in 1986 (= zero) and in 1988 (= 2 years)

	Mesial		Buccal		Distal		Lingual	
	T	C	T	C	T	C	T	C
Zero	29	28	8	10	34	31	12	16
2 years	28	24	13	8	34	29	16	15

Of the 167 crowns examined after 2 years, 149 had Isosit as veneering material and 18 had Dentacolor by the Silicoater Technique. The deteriorations noted for Surface and Color and for Anatomic Form from excellent to acceptable were related almost only to Isosit and the deteriorations from satisfactory to not acceptable only for Isosit. All crowns with Dentacolor as veneering material showed satisfactory results for the factors Surface and Color and Anatomic Form; in fact, a vast majority were given the rating excellent. Only very small changes were found during the 2-year follow-up period between the levels excellent and acceptable (Table 4).

Bleeding Index

The comparisons for bleeding are restricted to 0 and 2 years (Table 5). There seemed to be minor increases in bleeding buccally and lingually in teeth provided with titanium crowns and a minor decrease in bleeding mesially in control teeth. However, these differences between zero- and 2-year ratings were small, approaching some 4–5%. All other comparisons showed extremely small differences.

Margin Index

This factor has for obvious reasons been registered only on teeth provided with titanium crowns. The subgingivally located margins—degree 3—increased in number at all surfaces from 0 until the 2-year control (Table 6). A corresponding decrease could be noted for the number of restoration margins level with gingival margin, degree 2. For the margin locations with degrees 0 and 1 only minor differences occurred.

Table 6. Percentage of surfaces with Margin Index recorded in accordance with Silness (7) for the 167 titanium crowns that could be examined both in 1986 (= zero) and in 1988 (= 2 years). 0 = restoration margin more than 2 mm above the gingival margin; 1 = restoration margin less than 2 mm above the gingival margin; 2 = restoration margin level with the gingival margin; and 3 = restoration margin below the gingival margin

Margin index	Mesial		Buccal		Distal		Lingual	
	Zero	2 years	Zero	2 years	Zero	2 years	Zero	2 years
0	0	0	2	2	0	0	2	0
1	1	1	7	9	1	1	17	17
2	24	11	58	43	20	12	59	53
3	75	87	33	46	78	87	22	30

Discussion

Of the initial 149 patients 124, or 84%, could be examined after 2 years. The reasons of the other 25 patients for not attending do not indicate any association with factors pertaining to the study.

In any longitudinal study in which decisions are made in accordance with so-called independent observers with subjective evaluation criteria there is a possibility that the evaluators in the long run unconsciously will be influenced by each other and/or by the circumstances under which they are working. The examiners may therefore change their decision levels over a time period. Some few ratings in the present study, such as Anatomic Form and Margin Integrity in Table 4, may be the consequence of such influences. However, such potential influences do not seem to have had any decisive importance for the main conclusions to be drawn from the present study.

The retention of the cemented crowns seemed to be good. No crown had come loose during the 2-year period.

The marginal fit of all titanium crowns was satisfactory both initially and after 2 years. The vast majority of the margins were rated as excellent during the follow-up period. The other margins were rated acceptable. At the clinical examination of the crowns the impression was that the marginal fit was as good as that of well-fitting cast crowns in high-gold alloys. These findings indicate that the method used for fabrication of the titanium copings (3) has great potential for the future. It does not seem to be an exaggeration to state that with the present method the accuracy of the marginal fit of the copings is almost exclusively dependent on the operative skill of the clinician.

The present study included single crowns only. As titanium components fabricated with the present method can be successfully joined by laser welding (8), there is a good potential for the use of the fabrication method for bridges too.

The veneering material used in about the first 90% of the crowns was Isosit. During the 1st year this material disclosed shortcomings such as veneer fractures and several changes from excellent to acceptable with regard to the factor Surface and Color (3). These shortcomings became more pronounced during the 2nd year with some further veneer fractures and changes for both Surface and Color and Anatomic Form from satisfactory to not acceptable. These significant deteriorations are related to the veneering material Isosit. The fractures registered indicate that Isosit is incompatible with titanium copings fabricated with the present method, and the changes in Surface and Color and in Anatomic Form indicate that Isosit is less suitable as veneering material on the whole. With Dentacolor, however, the results after 2 years are still satisfactory. The bonding between the titanium copings and the Dentacolor veneering material was still functioning, and no fractures had occurred. However, it should be noted that the number of crowns with Dentacolor was small compared with that with Isosit. The present satisfactory results for Dentacolor are in agreement with those of Ekfeldt & Øilo (9) and also with those of an ongoing clinical study of another patient material provided with titanium crowns/bridges veneered with the Dentacolor-Silicoater technique (B. Bergman, H. Nilson, M. Andersson. Unpublished observations).

The installation of artificial crowns may, owing to improper marginal fit of the crowns and/or increased plaque accumulation, lead to an obvious increase of gingival inflammation. In the present study the very small changes noted for Bleeding Index after 2 years may reflect the satisfactory results obtained for margin integrity with the method used for fabricating the titanium copings (3).

The increases in the number of subgingivally located margins between 0 and 2 years were comparatively small. The increases buccally and lingually may be the result of a slight inflammatory hypertrophy of the gingiva; small increases in Bleeding Index were noted in these regions. Another explanation may be that the gingiva at the zero registrations still was influenced by operative procedures as, for example, tissue displacement or electrosurgical techniques preceding the impression procedure. Furthermore,

when judging Margin Index it is sometimes difficult to differentiate between the degrees, especially between levels 2 and 3.

In conclusion, the study has shown the following: with the present method for fabricating titanium copings (3) the initial Margin Integrity was satisfactory and remained so throughout the 2-year period; the vast majority of the margins were rated excellent. After 2 years veneers made with the Dentacolor-Silicoater technique were superior to those made with Isosit.

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