

A 3-year clinical study of alternatives to high noble dental casting alloys type 3

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For the purpose of evaluating the quality of dental casting alloys, 22 patients were recalled for clinical examination 3 years after insertion of crowns and bridges made from the low-gold alloy Midas® and the silver-palladium alloy Albacast®. A high-gold alloy, JS C®, served as a reference alloy. The examination included registrations of tarnish, plaque index, gingival index, and margin index. In addition, the California Dental Association's quality evaluation of dental care was used by two independent calibrated examiners. From the results of the present study it can be concluded that the crowns made from the alloy Midas in the annealed condition and the alloy Albacast are well suited for clinical use. Some tarnish appeared, but this may occur intermittently. □ *Clinical performance; dental alloys; high-gold alloy; low-gold alloy; silver-palladium alloy; tarnishing*

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Although long-term clinical studies of alternative dental casting alloys are highly desirable, only a few have been published. The results of these studies are mainly based on fairly short observation periods, such as approximately 1 year (1–3). The principal observation in these studies was that somewhat more tarnish was seen for alloys with a reduced content of gold or without gold altogether. Also, more roughness was seen on the surfaces of some of the alternative alloys (2, 3). Sturdevant et al. (4), who evaluated 15 low-gold casting alloys after 8 years, noted some loss of polish and tarnish, although the authors concluded that these surface changes were well within the ranges for clinical acceptability. The results of the latter study are in agreement with the short-term studies (1–3).

When evaluating alternative dental casting alloys, the risk of tarnishing and roughness formation is the most obvious potential disadvantage, but a possible influence on the soft tissues should not be neglected. Landesman et al. (1) and Letzel et al. (2) did not find any correlation between the gingival inflammation and the different alloys

studied. Unfortunately, the gingival status was not evaluated by Sturdevant et al. (4) in their 8-year study. Thus, only short-term clinical data on the correlation between gingival inflammation and alternative alloys exist. Therefore, the aim of the present study was to follow up the results of the previous 1-year report (3) with special attention to tarnish, roughness formation, and changes in the oral mucosa adjacent to the restorations made from alternative dental casting alloys.

Materials and methods

The design of the study, such as patient selection criteria, randomization, sex and age distribution, pretreatment anamnestic data and clinical examination, and treatment procedures, are described in the 1-year report (3). The alloys studied were a low-gold alloy (Midas®) and a silver-palladium alloy (Albacast®), both of them commercially available. A high-gold alloy type-3 (JS C®) was used as reference material. The metal content of the alloys as analyzed by X-ray fluorescence is presented in Table 1.

Table 1. Chemical composition determined by X-ray fluorescence analysis (Analytica AB, Sollentuna)

Alloy trade name	Manufacturer	Chemical composition, weight %								
		Au	Pt	Pd	Ag	Cu	Zn	In	Sn	Ir
JS C	J. Sjöding AB	76	3.0	<0.1	8.5	11.5	0.5	<0.1	<0.2	0.04
Midas	J. F. Jelenko & Co.	47	<0.1	6.5	37	8.0	0.95	<0.1	<0.5	<0.1
Albacast	J. F. Jelenko & Co.	<0.5	<0.1	26	68	0.02	2.3	3.0	<0.5	≤0.1

Table 2. Distribution of patients and crowns/retainers in relation to treatment centers and alloys

	No. of patients			No. of crowns/retainers		
	JS C	Midas	Albacast	JS C	Midas	Albacast
Umeå	17	8	9	24	9	11
Malmö	5	3	2	7	7	3
Total	22	11	11	31	16	14

Castings made of the alloy Midas were annealed for 1 h at 100°C below the solidus temperature ($T_{sol} = 843^\circ\text{C}$) and quenched in water before being used (5), whereas castings made of the alloys JS C and Albacast were used in the as-cast condition. Midas was used in the annealed condition because of the favorable effect of the annealing on the microstructure (5) and corrosion resistance (6).

In the spring of 1986, 17 patients in Umeå and 6 patients in Malmö were provided with crown- and bridge-work made from alternative casting alloys. Each patient received two restorations, one of them made from one of the alternative alloys and the other from the reference alloy. The alternative alloys to be used were randomized, as was the alloy to be used for any certain restoration. No control group was needed because of the intraindividual method of assessment.

At the 3-year recall, in the spring of 1989, one of the patients in Malmö had died. The other 22 patients had 31 crowns/retainers made of the alloy JS C, 16 crowns/retainers made of the alloy Midas, and 14 crowns/retainers made of the alloy Albacast (Table 2).

The patients were interviewed about 1) their medical history, including medication and allergies; 2) their opinion on the res-

torations made; 3) symptoms like headaches and sore mouth; and 4) smoking habits. The clinical evaluation procedures included registration of the status of the oral mucosa, the temporomandibular joint, and the masticatory muscles; tarnish of the alloy surfaces (Table 3) in accordance with an index proposed by Bessing & Fagerlund (7); margin index (8); bleeding on probing (9); and plaque index (9). When assessing these periodontal indices we chose homologous teeth for control purposes.

In addition, every experimental restoration was examined in accordance with the California Dental Association's (CDA) criteria (10) by two independent and calibrated evaluators (11). The CDA criteria focus on 'Surface and Color', 'Anatomic Form', and 'Marginal Integrity', and every restoration is given a rating representing one of four

Table 3. Criteria for tarnish index (7)

Score	Criteria
0	Smooth surface of alloy, only slight overall loss of metal gloss
1	Complete loss of metal gloss
2	Discoloration of alloy impossible to remove with cotton pellet, no pitting
3	Severe, general, discoloration but no pitting

ranges: 1) 'range of excellence', 2) 'range of acceptability', 3) 'replace or correct for prevention', and 4) 'replace immediately'. Restorations rated within ranges 1 and 2 are considered 'satisfactory', and restorations rated within 3 and 4 are 'not acceptable'.

Results

After 3 years 22 patients of the initial 23 could be examined. Thirty-one of 32 JS C crowns (97%), 16 of 17 Midas crowns (94%), and all 14 Albacast crowns were available for re-examination.

The anamnestic findings at the 3-year examination showed only small changes as compared with the 1-year results. One patient in the Midas group had started smoking cigarettes, and one patient in each group complained of having a sore mouth (Table 4). As compared with the 1-year examination, one more patient in the Albacast group had a mucosal affection—that is, aphthous stomatitis of the palate without direct relation to the experimental restorations (Table 5). The inflamed ectopic salivary glands of the lower lip of one of the patients and the lichenoid mucosal affection of the right buccal mucosa of another patient, which were evident at the 1-year examination, remained unchanged at the 3-year examination. Some changes with regard to signs of craniomandibular dysfunction were recorded. The number of patients with joint signs increased somewhat in the Midas group (Table 5).

Table 4. Number of patients with certain anamnestic findings in relation to alloys used

Findings	Alloys			
	Midas (n = 11)		Albacast (n = 11)	
	1 year	3 years	1 year	3 years
Drugs	3	1	2	2
Allergy	1	1	0	0
Tobacco consumption	3*	4*	1†	1†
Sore mouth	0	1	0	1

* Cigarettes.
† Snuff tobacco.

Table 5. Number of patients with certain clinical signs in relation to alloys used

Signs	Alloys			
	Midas (n = 11)		Albacast (n = 11)	
	1 year	3 years	1 year	3 years
Mucosal affections	1	1	1	2
Masticatory muscle signs	1	1	2	3
Joint signs	1	3	2	1

The 3-year examination by independent calibrated clinical evaluators using the CDA criteria (10) resulted mainly in ratings within the range of excellence. Some changes were rated within the range of acceptability (Table 6). All restorations were rated satisfactory, which means that there was no need for

Table 6. Number and percentage of crowns/retainers with a not excellent (but satisfactory) CDA rating with reference to alloys used*. The 1-year and 3-year results

CDA scores	JS C (n = 31)				Midas (n = 16)				Albacast (n = 14)			
	1 year		3 years		1 year		3 years		1 year		3 years	
	n	%	n	%	n	%	n	%	n	%	n	%
SRO	10	31	11	35	5	29	9	56	9	64	6	46
SCR	0	0	1	3	3	18	1	6	0	0	1	7

* SRO = surface of restoration is slightly rough or pitted; can be polished; SCR = visible evidence of slight marginal discrepancy with no evidence of decay; repair can be made or is unnecessary.

Table 7. Percentages of surfaces with plaque (Lenox & Kopczyk (9)) in relation to alloys used*

	JS C		Midas		Albacast	
	E, n = 31	H, n = 14	E, n = 16	H, n = 5	E, n = 14	H, n = 8
Before treatment	36	66	35	95	52	63
After 2 months	25	48	18	70	21	53
After 1 year	27	32	27	40	34	34
After 3 years	45	61	52	75	54	59

* E = experimental teeth; H = homologous teeth.

correction or replacement. The frequency of the rating SRO (a slightly rough or pitted surface that can be polished) of crowns/retainers showed that the differences between the alloys had decreased since the 1-year examination. There was almost no change in the JS C group, but the number of Midas crowns showing SRO increased, whereas the number of Albacast crowns decreased. SCR (visible evidence of slight marginal discrepancy with no evidence of decay) was seen in three cases—that is, in one crown in each alloy group. Owing to decay repair had been made at the margins before the examination in one JS C and one Albacast crown.

One JS C crown showed discoloration of the alloy (tarnish score 2) at the 3-year examination. With regard to Albacast the number of tarnished crowns (tarnish index score 2) decreased from 3 after 1 year to 1 after 3 years. None of the Midas crowns showed any tarnish.

The presence of dental plaque on crowned teeth (experimental teeth (E)) and on hom-

ologous teeth (H) is presented in Table 7. Plaque was seen on approximately 50% of the surfaces of the experimental teeth, with only small differences between the alloys, and was more often seen on homologous teeth than on experimental teeth. For JS C and Midas, dental plaque was seen more often after 3 years than before treatment and at the 2-month examination. For Albacast the plaque percentages increased from the 2-month examination to the 3-year examination, but the percentage before treatment was almost the same as at 3 years.

After 3 years there was a somewhat higher percentage of bleeding on the surfaces of Albacast crowns than on JS C and Midas crowns (Table 8). For Midas and JS C bleeding was seen more often than on homologous teeth after 3 years. Compared with the baseline registration the percentage of surfaces with bleeding after 3 years was almost the same for JS C and Albacast but somewhat greater for Midas. The differences between the alloys with regard to subgingival margins (MI3 = margin index score 3) were primarily

Table 8. Percentages of surfaces with bleeding (Lenox & Kopczyk (9)) in relation to alloys used*

	JS C		Midas		Albacast	
	E, n = 31	H, n = 14	E, n = 16	H, n = 5	E, n = 14	H, n = 8
Before treatment	20	23	18	10	29	34
After 2 months	18	25	16	0	16	25
After 1 year	16	21	31	5	25	28
After 3 years	18	17	23	7	30	17

* E = experimental teeth; H = homologous teeth.

Table 9. Comparisons of percentages of Margin Index score 3* (MI3), bleeding on probing (BOP), and plaque index in relation to alloys used (PII)

	JS C, n = 31			Midas, n = 16			Albicast, n = 14		
	MI3	BOP	PII	MI3	BOP	PII	MI3	BOP	PII
After 2 months	27	18	25	22	16	18	27	16	21
After 1 year	28	16	27	25	31	27	32	25	34
After 3 years	33	18	43	39	23	52	30	30	58

* MI3 (margin index score 3) = restoration margin below the gingival margin (Silness (8)); BOP = bleeding on probing, and PII = presence of plaque (Lenox & Kopczyk (9)).

rather small, but the Midas crowns showed a substantial increase in the percentage of MI3 up to the 3-year examination (Table 9). For Midas this was also the case with plaque index, for which the percentage increased almost threefold. However, a corresponding increase in the percentage of bleeding on probing could not be seen.

Discussion

After 3 years all patients but one were available for re-examination. The deceased patient had received 1 Midas and 1 JS C crown only. The reason for not attending the re-examination together with the small number of lost units indicates that there is no reason to believe that this loss of one patient influenced the results of the 3-year examination.

The small changes noted in anamnestic findings (Table 4) as compared with the situation 2 years earlier do not seem to be related to the differences in clinical behavior of the alloys used. The mucosal affections present (Table 5) were small and did not show any close relation to the experimental restorations, and it is therefore not likely that the alloys studied have had any irritating effect on the oral mucosa. The number of patients with signs from the craniomandibular system (Table 5) was the same in the Midas group as in the Albicast group. Parafunctional activities as evidenced by the signs of mandibular dysfunction may contribute to the slight roughness found in the crowns/retainers (Table 6).

Even though the CDA examiners were

calibrated to a predetermined level of inter- and intra-examiner agreement to maintain standardized evaluations, the risk of slide in judgements cannot be disregarded. This is especially evident in a longitudinal study. At the 1-year follow-up study SCR (visible evidence of slight marginal discrepancy with no evidence of decay) was seen in three cases, all in crowns made from the alloy Midas. Two years later, only one Midas crown showed SCR, whereas a new SCR rating was found in one JS C crown and in one Albicast crown. This could only be explained by the drift in clinical judgements, since marginal discrepancies cannot 'heal'.

The commonest CDA rating was SRO (a slightly rough or pitted surface that can be polished) at both the 1-year and the 3-year follow-up study and was attributed to slightly rough, scratched surfaces only. These surfaces were not restricted to functional contact area but were located all over the lingual areas of the crowns/retainers. Several explanations of this roughness exist. First, because of the location of the roughened areas it might be suggested that the slight roughness found by the CDA examination was due to wear from foodstuffs and toothbrushing. Second, wear due to functional/parafunctional activities can also explain the roughness. Another explanation might lie in the surface deterioration as a result of corrosion. These two processes might also coincide synergistically. Last, alloy characteristics such as hardness and toughness may contribute to the surface roughness. Accordingly, at the 1-year examination Albicast crowns showed the highest percentage of SRO ratings, twice as often as JS C and Midas crowns (Vicker's

hardness, Hv 5/10: JS C, 145; Midas, 178; and Albacast, 118 (5)). However, after 3 years Midas showed roughened surfaces much more often than JS C, whereas the number of SRO ratings in the Albacast group decreased (Table 6). Midas, being the hardest of the alloys used, ought to be the most resistant to roughening due to wear, and Albacast the least. Therefore, the only reasonable explanation of these differences between alloys with regard to roughness formation is supposed to be the slide in judgement just discussed.

Of the three Albacast crowns tarnished at the 1-year examination, only one remained tarnished after 3 years. The two Albacast crowns that lost their tarnish had been placed one each in the mouths of a man and wife. As mentioned in the 1-year study (3), according to a 4-day dietary history, no evidence of foodstuffs that might explain the tarnish was found. Despite this lack of evidence, it is supposed that there must exist a common environmental factor that could explain why both these Albacast crowns were tarnished at the 1-year control but not at the 3-year follow-up study. Moreover, it was apparent that even the high-gold alloy JS C tarnished in one case. This is in agreement with an *in vivo* tarnish study (7), in which 4 specimens of 10 from the alloy JS C tarnished to some extent after 16 weeks. Although the number of examined crowns was rather low, it seems reasonable to suggest that tarnishing may not be a major problem with regard to the low-gold alloy Midas and the silver-palladium alloy Albacast. However, tarnishing should not be disregarded but be further examined in future clinical investigations.

There were no major differences among the alloys with regard to the presence of dental plaque (Table 7) after 3 years. The increase in percentage of surfaces with plaque from 1 to 3 years may be explained by loss of interest in hygiene measures with time owing to less frequent visits to the dentists. This increase in percentages of surfaces with plaque is not accompanied by any corresponding increase in bleeding percentages (Table 8). The dichotomous scales are rather insensitive and take no notice of variations in quantity or quality. The quantity of plaque

might have an impact on the degree of gingival inflammation, which in turn may exist without bleeding on probing. This may to a certain extent explain the lack of correspondence. However, the use of dichotomous scales might be justified because of the simplicity of recording in clinical examinations.

The lack of correspondence between changes in percentages of surfaces with bleeding and the changes in percentages of subgingival margins and dental plaque from 1 to 3 years (Table 9), except for JS C, indicates that gingival health is also influenced by factors other than subgingival margins and dental plaque. From the results of the present study there is no clear evidence that the alternative alloys studied could be expected to harm the soft tissues more than traditional high-gold alloys.

On the basis of the present results it may be concluded, with the rather small number of crowns/retainers in mind, that the alloy Midas in the annealed condition and the alloy Albacast are well suited for clinical use. As with high-gold alloys, slightly roughened surfaces will appear with time. Some localized tarnish may also appear but seems to be intermittent. No more harm to the soft tissues might be expected from Midas and Albacast than from JS C.

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