Implant-Level Prostheses in the Edentulous Maxilla: A Comparison with Conventional Abutment-Level Prostheses After 5 Years of Use

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Purpose: Long-term comparisons of frameworks at the implant or abutment level are not available, and knowledge of the clinical function of cobalt-chromium (Co-Cr) alloy frameworks is limited. Primarily, the aim of this study was to compare the 5-year clinical performance of frameworks with or without abutment connections to implants. Secondly, the outcomes of prostheses made from Co-Cr alloy with porcelain veneers to those made of commercially pure titanium (CP Ti) with acrylic veneers were compared. ***Materials and Methods:*** The test groups comprised patients treated with screw-retained fixed prostheses made at the implant level according to the Cresco method in either dental porcelain–veneered Co-Cr alloy (n = 15) or acrylic-veneered CP Ti (n = 25). A control group of 40 randomly selected patients were provided with prostheses made at the standard abutment level in CP Ti with acrylic veneers. For all patients, clinical and radiologic 5-year data were retrospectively collected and evaluated. ***Results:*** Five-year implant cumulative survival rates (CSRs) were 98.6% and 97.6% for test and control groups, respectively ($P > .05$). No major differences in bone level were demonstrated between the groups after 5 years ($P > .05$). Significantly more complications occurred in the test groups compared to the control group ($P < .01$), with the most common complications being mucositis and fracture of veneers. ***Conclusions:*** After 5 years, the clinical outcomes of implant-level prostheses made of porcelain-veneered Co-Cr or acrylic-veneered CP Ti seem comparable to acrylic-veneered titanium prostheses made at the standard abutment level regarding implant CSR and bone levels. However, more complications were registered in implant-level prostheses compared to the standard abutment-level prostheses. *Int J Prosthodont 2011;24:158–167.*

Two of the main protocols for treating the edentulous arch with implant-supported fixed prostheses are the use of separate abutment cylinders and acrylic veneers.[1] Recently, alternative materials and methods have come into use, but little is known about how well they perform. Abutment-free techniques have been introduced to try to simplify the prosthodontic protocol for edentulous patients.[2] Among these techniques is the casting, sectioning, and laser-welding technique known as the Cresco method (Astra Tech).[3] Studies presenting short-term results of frameworks made at the implant level report few complications and no increase in bone loss compared to frameworks made at the abutment level, but the long-term effects are still unknown.[2,4,5]

The ability to restore implant patients without abutments has increased the risk for the use of materials other than titanium in the transmucosal portion of the implant prosthesis system, in direct contact with the peri-implant tissues. Animal studies have demonstrated normal soft tissue adhesion to titanium, but there is a lack of clinical data on the histology of human peri-implant soft tissues when different metals are used in the transmucosal components.[6]

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For decades, conventional tooth-supported fixed prostheses have primarily been fabricated with a metal framework and porcelain veneers.[7] However, when implant-supported prostheses for the edentulous arch were introduced, the standard solution was metal frameworks with acrylic resin veneers cured to the framework by means of acrylic resin.[1] Since the implants were regarded as being ankylotic in relation to the bone, it was considered important for the superstructure to be shock-absorbing to reduce loading on the implants.[8] When titanium frameworks were later introduced with lower costs and comparable or better fit, acrylic veneers were still the first choice.[9] Yet, a major complication was veneer fracture, especially in the edentulous maxilla.[10,11] Because of this and other esthetic reasons, porcelain veneers have become more popular.

There are a number of alternatives to high noble alloys to support porcelain veneers. In a review, Haag and Nilner[12] reported early problems with porcelain chipping in titanium-ceramic restorative systems, although this has become less of an issue as technical experience with these porcelain-fused-to-metal frameworks has increased. Further, Co-Cr alloys have a low price, favorable mechanical properties compared to high noble alloys, and equal or better bond strength to porcelain.[13] However, one disadvantage is that porcelain-veneered Co-Cr frameworks have higher laboratory costs than acrylic-veneered titanium frameworks, but this difference could be acceptable if the prosthesis results in fewer veneer fractures. Another disadvantage could be that the biocompatibility of Co-Cr alloys has been questioned,[14–16] and very little is known about their clinical performance in implant dentistry.[17–19]

The first aim of this 5-year follow-up study was to compare the clinical function between implant-supported prostheses in the edentulous maxilla made at the implant level (test groups) and prostheses fabricated at the abutment level (control group). A second aim was to compare prostheses made of Co-Cr alloy with porcelain veneers (Co-Cr test group) to two groups of prostheses made of titanium (commercially pure [CP] grade II) with acrylic veneers (CP Ti test group and the control group: Procera Implant Bridge [PIB], Nobel Biocare).[20]

Materials and Methods

The present retrospective study covers two groups of patients treated with fixed prostheses supported by implants in the edentulous maxilla at two different specialist centers and followed for 5 years. The first group of patients (test groups, n = 65) was treated with screw-retained fixed prostheses at the implant level between April 2002 and June 2004 at one specialist clinic (Specialist Prosthetic Clinic, Public Dental Health Service, St. Erik Hospital, Stockholm, Sweden). The second group of patients (control group, n = 40) was selected randomly from a group of 78 patients provided with standard abutment-level fixed prostheses and treated during a comparable time period (September 2001 to November 2004) at another specialist center (The Brånemark Clinic, Public Dental Health Service, Västra Götaland Region, Göteborg, Sweden).

Table 1 Distribution of Patients in Test and Control Groups

	Test groups		Control group
	Co-Cr	CP Ti	PIB
Men	6	12	19
Women	9	13	21
Mean age (SD) (y)	67 (12.5)	67 (11.5)	63 (12.1)
Age range	46–85	36–83	38–88
No. of smokers	3	5	22

SD = standard deviation.

Test Groups

Of the original 65 patients, 40 patients attended the 5-year follow-up examination and thereby formed the test group. They were provided with fixed prostheses at the implant level designed with frameworks of either Co-Cr alloy or CP Ti supporting porcelain or resin veneers, respectively. The patient distribution is presented in Table 1. The patients in the test group comprised 18 men and 22 women, with ages ranging from 36 to 85 years at implant placement. Eleven patients (27.5%) reported no general health problems or use of medication, and 8 patients (20.0%) reported smoking habits (Table 1). The dental status of the mandible at the time of implant placement is presented in Table 2.

Altogether, 246 implants were placed in the 40 edentulous maxillae using four different implant systems—none of which was provided with a turned surface (Table 3). All but three patients provided with Straumann implants (n = 18; Straumann) were treated using a two-stage surgical procedure according to the manufacturer's protocol, which was similar to the clinical protocol presented by Adell et al.[21] The three patients with Straumann implants were treated using a single-stage surgical procedure according to

Table 2 Status of the Mandible at the Time of Implant Placement

	Test groups		Control group	
Clinical status	Co-Cr	CP Ti	PIB	Total
Natural teeth with or without removable partial denture	9	14	24	47
Natural teeth and implant-supported prosthesis	1	6	15	22
Implant-supported prosthesis	4	5	1	10
Complete denture	1	0	0	1
Total	15	25	40	80

Table 3 Distribution of Implants (Prostheses) with Regard to System

	Test groups		Control group	
	Co-Cr	CP Ti	PIB	Total
Astra Tech	82 (13)	131 (22)*	0 (0)	213 (35)
Straumann	6 (1)	12 (2)	0 (0)	18 (3)
Biomet 3i	6 (1)	6 (1)	0 (0)	12 (2)
Brånemark System	0 (0)	3 (1)*	249 (40)†	252 (40)
Total	94 (15)	152 (25)	249 (40)	495 (80)

*One patient had 3 Astra Tech and 3 Brånemark System implants placed in the maxilla in the test group.
†Turned (n = 148) and TiUnite (n = 101) surfaces.

the Straumann surgical protocol.[22] The remaining 37 patients had healing abutments connected to their implants 3 to 6 months after implant placement. The distribution of implants with regard to implant system is presented in Table 3.

Prosthetic treatment began by removing the healing abutments, followed by a final impression at the implant level. Thereafter, all patients were provided with fixed screw-retained prostheses at the implant level. Altogether, 15 prostheses made in Wirobond C Co-Cr alloy (BEGO) with dental porcelain veneers (Classic, Ivoclar Vivodent) and 25 prostheses made in grade II CP Ti (Sjödings) with acrylic resin teeth (SR Vivodent/Orthotype PE, Ivoclar Vivodent) were fabricated according to the Cresco method.[3,23] Patients in the Co-Cr group received five to eight implants each (mean: 6.3, SD: 1.0), while the CP Ti group received five to seven implants each (mean: 6.1, SD: 0.5) (Table 3).

Control Group

Altogether, 101 patients were consecutively treated with fixed abutment-level implant prostheses in the edentulous maxilla, and 78 of these patients (77.2%) were followed for a period of 5 years. The control group (n = 40) was randomly selected from these 78 patients. The control group comprised 19 men and 21 women, with a mean age of 63.4 years at the time of implant placement (Table 1). Twenty patients reported no general health problems or use of medication (50.0%), and information on smoking habits was available for 36 patients (90.0%), of which 22 (61.1%) were smokers (Table 1). The dental status of the mandible at the time of implant placement is presented in Table 2.

In total, 249 Brånemark System straight implants (Nobel Biocare) were placed, of which 148 had a turned surface and 101 had a TiUnite surface (Table 3). Implants were placed according to a standard two-stage surgical procedure.[21] Sixteen patients had only implants with turned surfaces, 13 had implants with only TiUnite surfaces, and the remaining 11 patients had a mixture of both implant surfaces. The patients with a mixture of implant surfaces were essentially treated with turned implants, but TiUnite surface implants were placed in sites identified as being difficult.[24] However, since 1 patient with 6 turned and 2 TiUnite implants had only the turned implants connected, this patient was considered to have only turned implants supporting the prosthesis. Patients were provided with 4 to 8 implants each (mean: 6.2, SD: 0.80). After 3 to 4 months of healing, multiunit abutments or angulated abutments were connected.

Prosthetic treatment began with a final impression on the abutments, which were connected at stage-two surgery. All patients were eventually provided with computer numeric control–milled CP titanium maxillary prostheses (PIB) with acrylic veneers (Procera Implant Bridge and SR Vivodent/Orthotype PE), as described previously.[1]

Patients Lost to Follow-up

Forty percent of the eligible patients in each test group were lost to the 5-year follow-up, as well as 23% in the control group. The reasons for not attending the follow-up are presented in Table 4. Significantly more patients were noncompliant in the test groups compared to the control group ($P < .05$).

Table 4 Patients Lost to Follow-up

	Test groups		Control group
Reason for loss	Co-Cr	CP Ti	PIB
Deceased	0	7	6
Illness	1	0	3
Moved	1	1	3
Noncompliant*	8	7	11
Total	10	15	23†

*Significantly more patients were noncompliant in the test groups compared to the control group ($P < .05$).
†Based on the total group of 101 patients, of which 78 were followed for 5 years.

Registration and Follow-up

After prosthesis delivery, 16 patients in the test group (40%) and all patients in the control group had radiographs taken as a baseline registration of bone levels at the implants. Thereafter, patients were invited to clinical controls on an individual basis, but in general, at 1, 3, and 5 years after prosthesis delivery. Patients were advised to contact their clinic whenever they had any problems with their implants or prostheses.

After 1 year in function, intraoral apical radiographs were taken on a routine basis for the control group. At the final 5-year checkup, intraoral apical radiographs were taken for all but one patient in the test group, and the marginal bone levels were assessed to the closest 0.3 mm in relation to the different radiographic reference points.[25] The reference point was located at the same level as the most coronal portion of the peri-implant marginal bone was intended to be at the time of implant surgery, according to the surgical protocol for the respective implant system (Fig 1). For the Astra Tech implants, this was the most coronal portion of the implant periphery, and for the Brånemark System and Biomet 3i implants, it was the standard radiologic reference point[25] placed 0.8 mm apical to the implant-abutment junction. For the Straumann implants, the reference point was the coronal limit of the roughened surface, ie, the apical limit of the smooth implant neck (Fig 1). The mean value between the mesial and distal aspect of the implant was used for statistical analysis.[26] If an implant was measurable in more than one image, measurements were made in the image showing the most apical bone level.[27] The radiographs in the test groups were assessed by one of the authors, while the measurements in the control group were performed by specialists at the Specialist Clinic for Oral and Maxillofacial Radiology, Göteborg, Sweden, and verified by the research team. One month after the first measurement, one implant from each patient in the test group was randomly selected, and a second measurement was performed in the same manner as the first to assess intraexaminer variability.[27] Variation of the bone level in the 40 measured implants was 0.2 mm (SD: 0.3 mm).

Patient dental records were examined, and mechanical and biologic complications, as well as patient opinions, were recorded as in previous studies.[28–30] Registered mechanical complications included loose prostheses, implant component and framework fractures, veneer fractures, and loss of screw site fillings. Mucositis was registered when bleeding on probing, pus from the peri-implant sulcus, or peri-implant soft tissue edema was detected around any of the implants. The prostheses were only removed in the event of clinical symptoms or radiologic signs indicating loss of integration for any implant. Because of this, only survival criteria for the implants have been used, ie, no clinical or radiographic signs of lost osseointegration.[31,32] When additional implants were placed, they were not included when implant survival rates were calculated. Only surviving prostheses were included in the present study, according to the protocol.

Statistics

When appropriate, conventional descriptive statistics were used. Cumulative survival rates (CSRs) for implants were calculated according to life table analysis.[33] The chi-square test was used for categorical variables, ie, when analyses of differences in smoking habits, complication frequencies, and bone levels were performed. The Student *t* test was used for analysis of

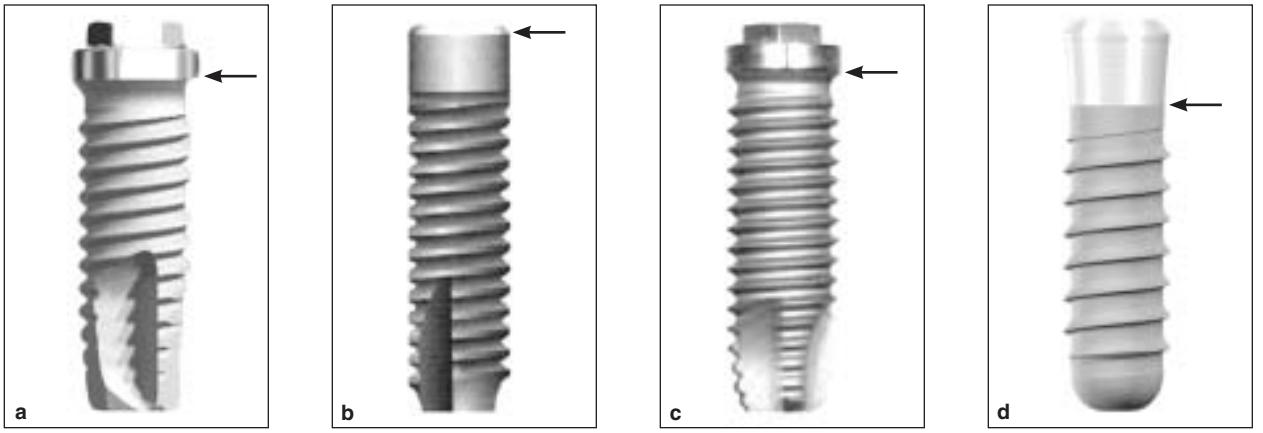

Fig 1 The four implants used with radiologic reference points indicated *(arrows)*. The radiologic reference points are located at the level where the most coronal portion of the peri-implant marginal bone was intended to be at the time of implant surgery, according to the surgical protocol for the respective implant system. **(a)** Brånemark System, **(b)** Astra Tech, **(c)** Biomet 3i, and **(d)** Straumann.

Table 5 Life Table of Placed, Withdrawn, and Failed Implants

	Test groups								Control group			
	Co-Cr				CP Ti				PIB			
Follow-up	Placed	With-drawn	Failed	CSR (%)	Placed	With-drawn	Failed	CSR (%)	Placed	With-drawn	Failed	CSR (%)
Implants	95	–	–	100.0	155	–	–	100.0	249	–	–	100.0
Prosthesis	94	–	1	98.9	152	1*	3	98.1	243	2†	4	98.4
1 year	94	–	–	98.9	152	–	–	98.1	243	–	–	98.4
2 years	94	–	–	98.9	152	–	–	98.1	243	–	–	98.4
3 years	94	–	–	98.9	152	–	–	98.1	243	–	–	98.4
4 years	94	–	–	98.9	152	–	–	98.1	242	–	1	98.0
5 years	94	–	–	98.9	152	–	–	98.1	241	–	1‡	97.6
Total	94	–	1	98.9	152	1	3	98.1	241	2	6	97.6
Loaded implants		–	–	100.0		–	–	100.0		–	–	99.2

CSR = cumulative survival rate.
*Implant lost at stage-two surgery and a new Astra Tech implant was inserted at the same appointment.
†Two implants (not connected) left unloaded.
‡Still integrated but decided to be removed after a total bone loss of 4.7 mm during the follow-up period.

the mean bone levels, and the Fisher exact test was used for the survival rate.[33] The level of statistical significance was set at 5% ($P < .05$), and statistical tests were only performed on the patient/prosthesis level.

Results

Implant Stability and Prosthetic Outcome

One Astra Tech implant in the Co-Cr group and three Astra Tech implants in the CP Ti group did not integrate and were removed prior to prosthesis delivery. Only one of these four patients was a smoker. No other implant failures were observed in the test groups (Table 5).

In the control group, six implants were lost: four before loading in four patients and the other two after 4 and 5 years in function in two other patients (Table 5). Five of the removed implants were provided with turned surfaces, and the only TiUnite implant was removed after 5 years, still in function but showing severe bone loss (4.7 mm). The remaining five failing implants with turned surfaces showed an average bone loss of 0.9 mm (range: 0.0 to 1.2 mm) during the follow-up period. Four of six patients with implant failures were smokers.

Significantly more patients were smokers in the control group ($P < .05$). The 5-year implant CSR was 98.6% and 97.6% for test and control groups, respectively (Table 5).

Table 6 Distribution of Prostheses with Complications During the Follow-up Period

	Test groups		Control group	
	Co-Cr (n = 15)	CP Ti (n = 25)	PIB (n = 40)	Total (n = 80)
Loose prostheses	0	1	0	1
Implant component fracture	0	0	0	0
Framework fracture	0	0	0	0
Veneer fracture	4	6	4	14
Loss of screw site filling	0	3	0	3
Wear	1	7	1	9
Redesigned occlusal table	0	1	3	4
Occlusal adjustment	1	1	0	2
Mucositis	5	11	10	26
Implant loss after connection	0	0	2	2
Phonetics	2	2	1	5
Lip biting	0	1	0	1
Others	1	0	0	1
Total	14	33	21	68
Mean (complication/patient)	0.9	1.3	0.5	0.9

During the 5-year follow-up period, 10 (25%) and 21 (53%) patients presented a clinical situation with no adjustments or comments in their files regarding their test or control prostheses, respectively. According to the inclusion criteria, all prostheses in both groups were still in function at the end of the study.

Maintenance

Table 6 presents the mechanical and biologic complications registered at the 5-year follow-up examination or reported in the dental records during previous years. Generally, the test groups displayed more complications per patient than the control group ($P < .01$). Statistically significantly more complications were revealed in the CP Ti test group compared to the PIB control group ($P < .001$). The Co-Cr test group tended to have more complications than the PIB control group, but this did not reach a statistically significant level ($P = .08$). No differences were found between Co-Cr and CP Ti test groups ($P > .05$). In addition, no statistically significant differences between the groups were found when single complications were examined (Table 6).

Mucositis was the single most frequent complication reported: 33.3% of patients in the Co-Cr test group, 44.0% in the CP Ti test group, and 25.0% in the PIB control group registered mucositis at least once during the 5-year period. No implant component or framework fracture occurred in the test and control groups during the 5-year follow-up period. Four patients (26.7%) in the Co-Cr test group had porcelain fractures recorded during the follow-up period. Slightly fewer acrylic veneer fractures were reported in the CP Ti group (n = 6, 24.0%) and the PIB group (n = 4, 10.0%) ($P > .05$). No specific dental status in the mandible could be related to veneer fracture.

Four prostheses, one in the CP Ti group and three in the PIB group, were redesigned by placing a new occlusal/palatal titanium table to protect the veneers in occlusion. The reason for this was generally because of severe veneer fracture, but in one PIB patient, it was due to extensive wear of the resin teeth.

Radiographs

One patient in the Co-Cr group with five Astra Tech implants did not allow radiographs to be taken. Another four Astra Tech implants in the CP Ti group were excluded from radiologic examination because of inadequate radiographs (Table 7). No differences in bone levels were seen between test and control groups ($P > .05$). One or more implants with bone levels located more than 2.3 mm apical to the reference

Table 7 Mean Marginal Bone Levels After 5 Years

	Test groups		Control group
	Co-Cr	CP Ti	PIB
No. of prostheses	14*	25	40
No. of implants	89*	148†	241
Marginal bone levels in relation to reference points (mm)			
Mean	1.00	1.30	1.20
SD	1.01	1.00	0.62
No. of implants with regard to bone levels (%)			
0–1.8 mm	71 (80)	109 (74)	203 (84)
1.9–2.4 mm	15 (17)	23 (16)	19 (8)
2.5–3.0 mm	0 (0)	7 (5)	9 (4)
≥ 3.1 mm	3 (3)	9 (6)	10 (4)

*One patient refused radiologic examination.
†Four implants were not measured because of inadequate radiographs.

point were present in two patients (13%) in the Co-Cr group, 11 patients (44%) in the CP Ti group, and 12 patients (30%) in the PIB control group.

In the control group, marginal bone loss was on average 0.5 mm (SD: 0.54 mm), where seven implants (2.9%) in six patients (15%) showed more than 2.4 mm of bone loss during the entire follow-up period.

Discussion

To the authors' knowledge, this is the first study that attempts to compare abutment and abutment-free implant prosthodontic protocols for complete prostheses in the edentulous arch. It is also thought to be the first 5-year follow-up study to present the clinical outcomes of implant-supported fixed prostheses made from Co-Cr alloy with porcelain veneers in the edentulous maxilla and to compare these to prostheses made according to more established protocols.

The clinical outcomes of implant-level prostheses made of porcelain-veneered Co-Cr or acrylic-veneered CP Ti seem comparable to acrylic-veneered titanium prostheses made at the standard abutment level regarding implant CSRs and bone levels. However, more complications were observed in the implant-level prostheses compared to abutment-level prostheses ($P < .05$).

The reported prevalence of mucositis was higher than previously reported (Table 6),[5,20] but there is no consensus on the definition of mucositis in general or between the two participating clinics. Since there is an obvious difference in tissue anchorage of teeth in comparison to implants,[34] the current similarity in evaluation methods for teeth (gingivitis) and implants (mucositis) and their association to bone loss is still open for discussion.[35,36]

Whether the higher prevalence of mucositis in the test group compared to the control group could be explained by the absence or presence of abutments is not possible to evaluate within the scope of this study. An in vitro study by Hjalmarsson et al[37] described a statistically significantly greater vertical misfit in implant-level Cresco frameworks compared to abutment-level PIB prostheses. However, even if there was a difference in fit to the implants between the frameworks in the test and control groups in the present study, there is no consensus regarding the biologic impact of such a misfit.[38,39] In addition, it seems reasonable that patient factors such as clenching and different experiences among clinicians with the applied treatment protocols influenced the differences in the prevalence of complications.

In theory, harder materials such as porcelain, compared to acrylic, and Co-Cr alloy, compared to titanium, preserve a smoother surface more easily and are more resistant to daily wear from function and tooth brushing. In this way, plaque retention could largely be reduced.[40,41] Consequently, in this respect, a Co-Cr and porcelain prosthesis may in theory be better than one made of titanium and acrylic. Yet, the knowledge of how Co-Cr materials behave in the transmucosal peri-implant zone is limited, but they are considered to be less biocompatible than titanium.[14–16] Even so, no obvious differences in bone levels after 5 years in function could be observed, either with regard to mean levels or prevalence of implants with obvious apical levels (Table 7). More accurate variables, such as marginal bone loss, may have been more valuable and are indicated to be low in the control group, but it so far has been difficult to use historic data of bone levels or bone loss to predict potential implant failure.[42,43] A high implant survival rate was seen in all three groups, in accordance with earlier reported studies on Astra Tech and Brånemark System implants.[11,44–46]

No framework fracture occurred among the evaluated patients in the test or control groups. This was a frequently reported complication in earlier studies covering gold alloy frameworks and earlier generations of laser-welded titanium frameworks.[9,28,29,47] Increasing technical skill with CP Ti, both laser-welded according to the Cresco method and computer numeric control–milled (PIB), and the use of Co-Cr alloy frameworks can explain this decrease. Even though the use of Co-Cr alloy frameworks in implant dentistry is rather new, the favorable mechanical properties of the alloy may have influenced the result.[48]

The test group displayed about twice as many complications per patient than the control group during the 5-year follow-up period. Previous studies reported fewer complications for Cresco prostheses than the present study, but the prostheses included in these earlier studies were more heterogenous in origin: complete and partial in the maxilla and mandible.[2,4]

Porcelain veneer prostheses (Co-Cr) had the highest frequency of veneer fractures. However, this was not a statistically significantly difference from the other groups, probably due to few total observations ($P > .05$). The veneer fracture rate for the PIB prostheses is lower than earlier demonstrated.[20] Increased technical skill can explain these differences. Since acrylic veneer fractures have been long reported, it is tempting to suggest that porcelain veneers on a Co-Cr framework were chosen in the present test group in cases where a risk for acrylic veneer fractures were anticipated and to reduce future problems with veneer fractures.

Redesign of the occlusal table was performed in four patients with resin veneers but in none of the patients provided with porcelain veneers, despite a relatively high frequency of veneer chipping. These minor porcelain fractures were largely ignored by the patient or adjusted by the clinician with the prosthesis still in place. Yet, restoring a fracture or redesigning a porcelain occlusal table is far more complicated and time-consuming than the same procedure on acrylic-veneered prostheses.

Further and prospective studies are needed to evaluate if a costly metal-ceramic design has any major mechanical advantage over a less costly metal-acrylic alternative.

Conclusions

Within the limitations of this 5-year retrospective study on implant-supported prostheses, it can be concluded that:

- After 5 years, significantly more noncompliant patients were observed in the test group ($P < .05$).
- Biologic response in terms of mucosal inflammation and recorded bone levels at the end of the study did not reveal any significant differences between prostheses fabricated at implant and abutment levels ($P > .05$). However, a trend of implants with mucositis was more frequently observed in implant-level prostheses, possibly because of different prosthesis designs or different registrations/definitions at the two clinics.
- The 5-year CSRs for the implants were 98.6% and 97.6% for test and control groups, respectively ($P > .05$).
- Of a total 10 failing implants, 4 implants were lost from the test and 4 from the control group before prosthesis placement. Another 2 implants were lost in the control group after prosthesis placement. Five of 10 patients with implant failures were smokers.
- Prostheses made with Co-Cr frameworks and porcelain veneers show a similar clinical performance to comparable CP Ti prostheses with acrylic veneers. An observed trend of higher prevalence of porcelain veneer fracture, as compared to resin veneers, did not reach a significant level ($P > .05$).
- Approximately twice as many complications per patient were recorded in the test groups compared to the control group ($P < .01$). Overall, mucositis and veneer fractures were the most common complications recorded in the present study.

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Literature Abstract

A review of events that expose children to elemental mercury in the United States

The health effects associated with elemental mercury exposure vary with the magnitude and duration. Acute exposures often lead to respiratory problems such as pneumonitis, bronchilitis, and pulmonary edema. Chronic exposures are associated with hypertension and autonomous nervous dysfunction. Children are more sensitive to mercury and are at greater risk than adults. This report attempts to review existing data to identify common sources of elemental mercury exposure in children, to describe the location and demographics, and to make recommendations on preventing further elemental exposures. This review does not include mercury exposure associated with coal-burning facilities, dental amalgams, and fish. The exposure data were collected from federal, state, and regional programs that capture information on spills and other hazardous releases in 2006 and 2007 in the United States on children < 18 years of age. Some of them include the Agency for Toxic Substances and Disease Registry, Hazardous Substances Emergency Events Surveillance, and the US Coast Guard National Response Center database. In addition, data sources were supplemented with a literature search on publications documenting US-based exposures between 2002 and 2007. Based on the analysis of the data, most exposure scenarios occur at home and at school. In addition, medical clinics and former industrial properties not adequately remediated are the third most common exposure scenario. Most home-based exposure scenarios came from broken thermometers, barometers, thermostats, electric switches, natural gas regulators, and compact fluorescent light bulbs. Fortunately, mercury-containing devices are less common now, and, thus, exposures resulting from these devices should decline with time. School-based exposures normally came from science laboratories when using mercury-containing instruments. Some gymnasium floors also contain a mercury catalyst that releases vapor into the air. Mercury exposures can also occur in medical facilities and in buildings where mercury was used previously. The exposure to elemental mercury often results from inappropriate handling or cleaning of spilled mercury. Fortunately, review of existing data suggests that most releases do not lead to demonstrable harm if the exposure period is short and the mercury is properly cleaned up. Health education and policy initiatives are important in primary prevention of elemental mercury exposure. Coordinated efforts between existing surveillance systems are also paramount in identifying risk factors and implementing an effective prevention strategy for larger spills.

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