

# Galvano- vs. metal-ceramic crowns: up to 5-year results of a randomised split-mouth study

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**Abstract** Full-crown restorations made by galvano forming may be considered as highly biocompatible, stable and aesthetic restorations. Therefore, they represent an alternative to conventional metal-ceramic crowns (MC), which might be associated with an allergic or toxic reaction due to metal oxides. In current literature, there are few clinical reports available, but no comparative clinical evaluation of these two systems. Thus, the purpose of this clinical observation was to compare the long-term success of galvano-formed crowns (GC) and MC and to evaluate post-operative complications. The working hypothesis was that there was no difference in clinical success between crowns based on galvano-forming procedure or conventional metal-ceramic

crowns. A prospective, randomised, double-blinded clinical trial was conducted. 48 GC and 48 MC were placed in 48 periodontal healthy patients (male=24; female=24) in a split-mouth design. Prosthetic parameters as technical, biological and endodontic problems were recorded. Restoration survival—MC vs. GC—was compared using a non-parametric Chi-square test by McNemar at 5% level of significance. The crown restorations were re-evaluated after an observation time of 13 to 64 months (mean=40.5; SD=11 months). 45 GC and 45 MC (94%) were in situ without any complications. No significant differences were found between GC and MC. Surface conditions differed only in part. Fractures of the veneering material were observed in one (2%) and two (4%) for MC and GC, respectively. The presented data indicate that GC appears to be a successful alternative to conventional MC systems.

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## Introduction

Within the last decades, different crown systems have been introduced in order to optimise precision, stability and aesthetics. Nowadays, all-ceramic restorations have become state of the art in both anterior and posterior teeth. However, there are still problems concerning adhesion mechanism of the veneering porcelain to the framework causing chipping [1, 2].

The use of metal-ceramic crowns (MC) is well documented over a number of years. The clinical survival rates range from 92.4% after 7 years to 96% after 10 years [3] [4]. Närpänkangas et al. found a survival rate of 78% after 20 years of service [5]. MC is basically made of a cast

metal framework, containing non-precious metals. These are needed to form a superficial oxide layer mediating the connection to the veneering porcelain. Due to the casting process casted alloys, in particular noble and base metals, are associated with corrosion and release of metal ions. These have been postulated to be responsible for discoloration and hyperplasia of the adjacent gingiva. The risk of bleeding at intrasulcular posterior MC margins was found to be approximately twice that at supragingival margins [6].

Another alternative system to conventional MC is the restorations made by galvano-forming procedure. The metal framework is fabricated by a computer-controlled process of galvanisation. This involves the deposition of gold ions on a conductible surface under an electrical current, forming a highly precise gold coping with a proportion of gold of ~99.9% (GC). Galvano forming offers some advantages over metal-ceramic crowns. From aesthetic point of view, there is no dark metal framework to be discovered. Due to its high gold content, a natural and warm appearance is achieved when covered with porcelain. Moreover, absence of non-precious metals should prevent possible discoloration and corrosion at the gingival margin as observed with MC made out of base or noble alloys. Nevertheless, GC are not a popular technique for single crown restorations. The basic difference between MC and GC is the manufacturing process of the metal substructure. The impact on survival rates on respective restorations has not been demonstrated within a clinical observational study, although the results of possible periodontal tissue alterations have already been published [7]. Gingival tissues adjacent to galvano-ceramic crowns (GC) showed significantly less signs of clinical and inflammatory responses according to plaque index, gingival index, gingival crevicular fluid flow rate and IgG. These data suggested a stabilising effect of GC crowns on periodontal tissues over time. To date, comparative studies evaluating periodontal responses of all-ceramic versus galvano-ceramic restorations have not been published.

Hence, it was aim of the present study to compare survival rates and complications of MC and GC in a clinical pilot study of split-mouth design. The null hypothesis was that there was no difference between the clinical performances of both types of restoration.

## Materials and methods

A prospective, clinical pilot trial was conducted in a split-mouth design. From June 2001 to June 2004 patients visiting the dental school of the Charité–Universitätsmedizin Berlin with an indication for crowning of teeth were registered and screened for participation by the principal investigator. The following inclusion criteria had to be met by patient or teeth,

respectively: indication for crowning of contra lateral teeth of the same tooth group (i.e. front teeth, premolars and molars), vital teeth or adhesively post-restored teeth, and periodontal health displayed by a pocket depth  $\leq 3$  mm and no tooth mobility. Tooth mobility was checked with the tips of the handle of dental mirror and probe. A deflection of 1 mm and more was judged as increased mobility. Furthermore, subjects should show no clinical signs of bruxism as attrition of degree  $>II$  and willingness to join follow-up procedures over a 5-year interval.

The prosthetic treatment was performed by a single operator. The teeth were prepared with the opti-shape-preparation set (Hager & Meisinger, Düsseldorf, Germany). A 360 degree, 1 mm chamfer at the level of the gingival margin was prepared. Occlusal or incisal surfaces were reduced by 2 mm. The circumferential preparation was performed ensuring a 6° preparation angle. Impressions were made at the same appointment as abutments were prepared. A two-stage procedure using an addition curing silicone (Provil, Heraeus-Kulzer, Germany) was chosen. The crown type (MC or GC) was randomly allocated to the respective site using drawing lots. All individual MC (Degunorm®, Degudent, Germany) and GC (AGC®, Wieland, Germany) were manufactured using the respective veneering ceramic by the same dental laboratory. The crown fit was checked with a silicon material (Fit Checker White, GC, USA). The occlusion was controlled using shim-stock foil. An even distribution of occlusal contacts was ensured on both restored and not restored teeth. In the case of the need for occlusal adjustment, the ceramic surface was polished using Dialite II burs (Komet, Gebr. Brasseler, Germany). The crowns were conventionally cemented with zinc phosphate cement (Harvard, fast setting, Richter and Hoffmann, Berlin, Germany).

Follow-up examinations were performed by examiner, who was not the operator after 3, 6 and 12 month, and then in a yearly interval. The following clinical prosthetic parameters were assessed with a detailed questionnaire recording biological or technical complication such as:

- Loss of retention,
- Hypersensitivity,
- Need of endodontic treatment or extraction,
- Time since cementation,
- Surface conditions,
- Discoloration
- Marginal fit/secondary caries.

The quality of the crowns was determined by using a modified California Dental Association (CDA) grading. Each subcriterion was classified in four possible categories: Romeo = without defects, Sierra = with minor defects, Tango = with major defects, Victor = unacceptable. Additional influencing factors such as tooth guidance or level of abrasion [8] were evaluated and recorded.

## Statistical analysis

Restoration survival—MC vs. GC—was compared using a non-parametric Chi-Square test by McNemar. The level of significance was set at  $\alpha < 0.05$ . Crowns judged as needing replacement were judged as a complete failure.

## Results

A total of 52 GC and 52 MC were placed in 52 patients. Ninety-six crowns in 48 patients (24 female, 24 male) could be evaluated after a clinical service time of 13 to 64 months (40.5; SD 11 month). For four patients no information could be collected, representing a drop-out rate of 8%. The mean age was 44 years. Most patients (58%) showed a combined front-canine guided dynamic occlusion. The degree of attrition [8] ranged from degree I and II (92%) (Table 1).

Forty-five GC and 45 MC (94%) were in situ without any complications. They were assessed as Romeo or Sierra [9] with regard to marginal integrity, secondary caries, discoloration and anatomical form. “Excellent” surfaces were found in 24 (50%) GC and 23 (48%) MC. Acceptable surfaces were recorded for 20 (42%) GC and 23 (48%) MC. Fracture of the veneering material was observed for one (2%) MC and 2 (4%) GC. However, there was no need to replace one of these crowns. Three teeth needed endodontic treatment due to an irreversible pulpitis (two MC after 2 years, one GC after 3 years). Two (4%) teeth were lost due to a vertical root fracture and a persisting fistula, respectively (Table 2). The periodontal findings have been reported elsewhere [7]. There it was shown that GC may have a stabilising effect on the health of the marginal periodontal tissue.

**Table 1** Patients characteristics

	Galvano-ceramic	Metal-ceramic
Male	24	
Female	24	
Number of recalled restorations	48	48
Anterior crowns	11 (23%)	11 (23%)
Premolar crowns	12 (25%)	12 (25%)
Molar crowns	25 (52%)	25 (52%)
Attrition 0	4 (8%)	4 (8%)
Attrition I	22 (46%)	22 (46%)
Attrition II	22 (46%)	22 (46%)
Tooth guidance: canine	28 (58%)	28 (58%)
Tooth guidance: group	17 (35%)	17 (35%)
Tooth guidance: unilateral bal.	3 (6%)	3 (6%)

**Table 2** Type of complications and evaluation of surface

	Galvano-ceramic (n)	Metal-ceramic (n)
In situ without any complication	45	45
Surface excellent	24	23
Surface acceptable	20	23
Fracture of veneering material	2	1
Endodontic complications	1	2
Extraction necessary	2	-

The statistical analysis revealed no statistical significant difference between both types of restoration in regard to prosthetic parameters ( $p=0.9$ ; McNemar test).

## Discussion

After a mean time of observation of 40.5 months of clinical function, a survival rate of 94% was calculated for MC and GC restored teeth, respectively. No statistical significant difference was found for both types of restoration. The null hypothesis was confirmed. GC appear to be a successful alternative to conventional MC systems.

This is the first randomised controlled clinical trial comparing galvano-ceramic to metal-ceramic-crowns. To the best of our knowledge only one internationally published comparative in vitro study reports an evaluation of the fracture resistance of metal-ceramic, galvano-ceramic and all-ceramic crowns. The metal-ceramic crowns exhibited higher resistance to fracture compared to galvano-ceramic crowns. Both of which exceeded the maximum occlusal masticatory forces observed clinically [10]. However, since this is a laboratory study results may be not directly comparable to clinical results.

For the clinical behaviour of MC clinical evidence is available. Among the literature, Reitemeier et al. observed 190 single MC crowns in ten private practices for 7 years, with a success rate of 92.4% being reported [3]. Walton



**Fig. 1** Clinical example for single crown restoration of maxillary first molars in split-mouth design, MC metal-ceramic, GC galvano-ceramic

followed-up a total of 688 crowns, with 87% being re-evaluated after 10 years. The statistical analysis distinguished between two groups: group I which was in service for 5 to 10 years, and group II which was in service for less than 5 years, but more than one. The repair and failure rate was 3% for both groups. Success rate was 96% for a mean time of observation of 40 months. Corono-radicular and root fractures were the causes for the majority of 25 retreatments [4]. In another study, survival rate of 97.6% over 7 years were observed [11]. Erpenstein et al. compared galvano and glass-ceramic single crowns in a longitudinal clinical trial ( $n=717$ ). Patients were treated by two practitioners. Survival rates of 92% for anterior and 96.5% for posterior GC restorations were reported after 7 years of clinical function. However, no randomisation was reported [12].

Goodacre and co-workers performed a Medline and extensive hand search covering the last 50 years to identify the incidence of complications [13]. The searches focused on publications that contained clinical data regarding success, failure and complications. Within each type of prosthesis, raw data were combined from multiple studies and mean values calculated to determine what trends were noted in the studies. Data showed the lowest incidence of clinical complications associated with all-ceramic crowns (8%) followed by conventional single crowns (11%). The most common complications were crown fracture, veneering porcelain fracture, loss of retention and need for endodontic treatment [13]. A systematic review of single-tooth restorations supported by implants examined uncomplicated crown maintenance of 83% after 4 years. However, the crown material was specified and loss of retention was also defined as failure [14]. Systematic reviews point out the absence of comparative studies as well as different ways of defining success and among the different treatment modes [15, 16]. The results of the present study therefore compare favourably with the results of the studies reported above, demonstrating the viability of GC crowns, at least within the confines of the present study.

In future studies, it may be of interest to evaluate and compare MC and GC to the various all-ceramic crown systems which are becoming popular. Not only technical (i.e. fracture or shipping of the veneering material, connector size) but also biological aspects as the periodontal response are to highlight in future to evaluate a crown material.

## Conclusion

Within the limitations of the present pilot study it can be concluded that galvano-ceramic crowns seem to be an alternative to common metal-ceramic crowns (Fig. 1).

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**Conflict of interest** The authors declare that they have no conflict of interest.

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