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ORIGINAL ARTICLE

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Clinical performance of monolithic lithium disilicate hybrid abutment crowns over at least 3.5 years

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Abstract

Purpose: Hybrid abutment crowns (HACs) made from monolithic ceramics represent an efficient option for single restorations on implants. However, long-term data are scarce. The purpose of this clinical trial was to evaluate the survival and complication rates of CAD-CAM fabricated HACs over a time period of at least 3.5 years.

Materials and Methods: Twenty-five patients with a total of 40 HACs made of monolithic lithium disilicate ceramic bonded to a titanium base CAD-CAM abutment were retrospectively evaluated. All implants and screw-retained restorations were placed and manufactured in the same department of a university hospital. Only crowns that had been in service for more than 3.5 years were included in the study. HACs were evaluated regarding technical and biological complications. Functional Implant Prosthodontic Scores (FIPS) were obtained.

Results: The mean observation time was 5.9 ± 1.4 years. Implant survival was 100%, and HAC survival was 97.5%. Over the observation period, one crown fracture was observed, necessitating refabricating of the restoration. Three minor biological complications were found. The overall mean FIPS score was 8.69 ± 1.12 points.

Conclusions: Within the limitations of this study, monolithic screw-retained HACs milled from lithium disilicate ceramics and bonded to titanium bases appeared to be a reliable treatment option over more than 3.5 years due to their low biological and technical complication rates.

KEYWORDS
CAD-CAM, complications, dental implant, hybrid abutment crowns, lithium disilicate, monolithic restorations

The digital transformation in dentistry and advances in computer-aided design and computer-aided manufacturing (CAD-CAM) are subjecting accustomed workflows to significant changes.[1] The manufacture of dental restorations from prefabricated materials in standardized processes provides advantages in terms of efficiency, quality, and long-term prognosis.[2] Prosthetic-driven implant planning, implant placement, and in particular implant-supported restorations benefit from modern digital workflows, which comprise data acquisition, data processing, and the fabrication of the work-piece, for example, the crown.[3] Oral implants and implant-supported single-tooth restorations are vital elements of contemporary restorative dentistry because of their low incidence of complications and excellent success and survival rates.[4–6]

Conventional porcelain-fused-to-metal crowns (PFM) or veneered crowns with ceramic frameworks hold increased susceptibility to veneering fracture, commonly known as "chipping".[7] Single implant crowns (SICs), especially, have proven prone to specific technical complications, such as the fracture of the veneering material.[4] To render pointless the disadvantages of veneered restorations and to streamline processes, monolithic materials in combination with digital protocols seem to be an intriguing option.[8,9] Although there are different ceramic and resin-based tooth-colored monolithic materials for implant single crowns,[10–14] lithium disilicate ceramics are being widely used in clinical routine, and have repeatedly been the focus of clinical scientific interest.[15–18]

The combined and effective use of different types of materials and their specific properties seems to be of special interest in implant prosthetics. Implant hybrid abutments and hybrid abutment crowns (HACs), which comprise a metal base abutment and ceramic restorative materials, have proven reliable in implant-supported single-unit restorations[19–22] and even advantageous over one-piece ceramic abutments.[23,24] The fact that most HACs are, by their inherent design, screw-retained offers additional advantages.[18,25–27] However, since the straightforwardness of the procedure and economic aspects become increasingly important, the manufacture of restorations from monolithic materials such as lithium disilicate (LS2) and zirconia (ZrO2) ceramics has become broadly established. With favorable esthetics,[28] exceptional physical properties, and excellent biocompatibility,[29,30] they meet many of the requirements of modern dentistry.[31–33] A complete digital workflow without the need for physical models is feasible only when using monolithic restorative materials in digital protocols.[34] At the same time, they also allow a customizable combination of analog and digital processes. These reasons make monolithic ceramic materials a perfect fit with CAD-CAM-based dental and technician workflows.

Lithium disilicate ceramics can be applied in tooth- and implant-supported prosthodontics, inter alia as a material for single crowns and fixed partial dentures, for veneers, inlays, onlays, and overlays. Looking at two surveys among dentists, lithium disilicate ceramics was the treatment option for tooth-supported crowns that was most favored if a completely dry operating field for the adhesive procedures can be guaranteed.[35,36] Even if these two studies do not include implant-supported dentures, it may be postulated that this material is an efficient and competitive option in implant-supported single-tooth restorations.

Pjeturrson et al. listed several studies on reinforced monolithic glass-ceramics in their recent systematic review on all-ceramic SICs.[6] However, only a single investigation[37] describes clinical data over more than 5 years, and includes only 15 HACs fabricated from monolithic lithium disilicate ceramics.[6] Hence, long-term clinical data on implant-supported lithium disilicate HACs are currently scarce in scientific literature. Therefore, the purpose of this retrospective clinical study was to assess technical and biological complications in monolithic HACs over a longer period with a greater number of crowns. To address this issue, a systematic evaluation method for posterior implant crowns, the Functional Implant Prosthodontic Score (FIPS),[38–43] was employed. Hypotheses are that survival and success rates are high and that FIPS is comparable to existing data.

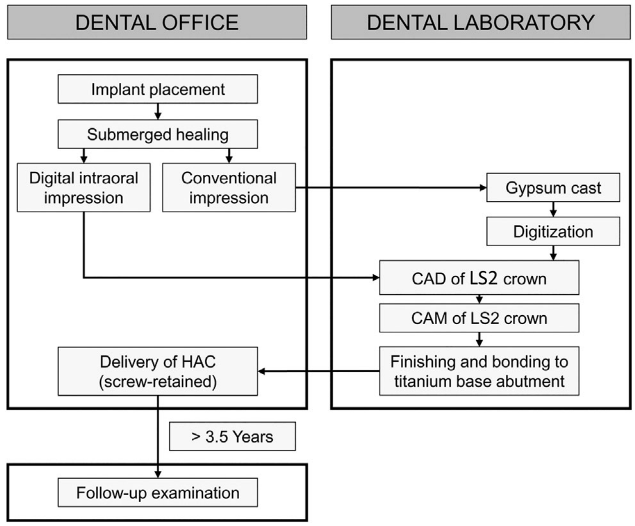

FIGURE 1 Clinical and laboratory treatment and manufacturing protocol of the hybrid abutment crowns (HACs) fabricated in this study.

MATERIALS AND METHODS

The present study was a retrospective monocentric in vivo study with a follow-up period of at least 3.5 years up to 9 years. The ethics committee of the medical faculty of the Ludwig-Maxmilians-University Munich (application number 21−0624) granted approval. The STROBE checklist was adhered to.[44] All treatments and follow-up examinations were conducted at the Department of Prosthetic Dentistry, University Hospital, LMU Munich, Munich, Germany.

Inclusion criteria for potential study participation were patients with at least one CAD-CAM fabricated hybrid abutment single-implant restoration in the posterior region. All crowns were fabricated in a CAD-CAM-based protocol and compromised a titanium base CAD-CAM abutment and crown made of monolithic lithium disilicate ceramic (IPS e.max CAD, Ivoclar, Schaan, Liechtenstein) (Figures 1 and 2). The HACs had to have been delivered at least 3.5 years ago. Implant insertion, prosthodontic treatment, and crown manufacturing were performed by clinical and laboratory professionals of the Department of Prosthetic Dentistry, University Hospital, LMU Munich. Retrospective case selection was conducted by screening the records of all patients who received dental implants between 01/01/2010 and 08/01/2018. Clinical follow-up examinations were conducted between 08/01/2021 and 03/01/2022. An example of the clinical and radiographic appearance of a HAC over time is given in Figure 3.

Twenty-five participants (mean age: 63.6 ± 12.5 years, 11 female, 14 male) with at least one screw-retained hybrid abutment crown were included, resulting in a total of 40 crowns. All patients were examined by trained investigators [OS, TG, and JG]. Clinical examination of the restorations, standardized radiographs of the implants with right-angle technique, and photographic documentation were performed. The dates

FIGURE 2 Components of a HAC that replaced a mandibular molar (example) from left to right. Titanium base CAD-CAM abutment and screw, milled crown in the lithium metasilicate phase, after sinter-firing, after glaze-firing; and lithium disilicate crown adhesively bonded to the titanium base abutment.

FIGURE 3 Photographs (upper left: delivery, upper right: recall examination) and radiographs (lower left: delivery, lower right: recall examination) of a screw-retained HAC that replaced the mandibular left first molar (exemplary). The interval between examinations was 4.1 years and the total FIPS score was 10.

of delivery of the crowns, other relevant data, and all adverse events were extracted from the patients' medical records, including type and time of complications. The complications were classified into "technical" and "biological" (Table 1).

The FIPS was applied to all HACs to assess the prosthodontic outcome of the treatment.[42] The evaluation index comprises five parameters (Table 2): "Interproximal", "Occlusion", "Design", "Mucosa", and "Bone". A score of 0-1-2 was assigned for each variable, giving a maximum score of eight (5 × 2). The criteria "Design", "Mucosa", and "Bone" were validated by a second investigator based on clinical photographs.

TABLE 1 Potential complications with CAD-CAM fabricated hybrid abutment single implant restorations made of monolithic lithium disilicate ceramics.

Technical complications	Biological complications
Fracture of ceramic	Tissue dehiscence
Screw loosening	Peri-mucositis
Screw fracture	Peri-implantitis
Loss of retention between crown and titanium base CAD-CAM abutment	Implant loss
Loss of sealing composite resin of the screw access opening	
Implant fracture	

Statistical analysis was performed using SPSS (SPSS Statistics, 24.0, IBM, Armonk, NY, USA). FIPS were tested for normal distribution applying the Kolmogorov Smirnov test and descriptive statistics were calculated. The level of significance was set at $p < 0.05$.

RESULTS

The mean follow-up time was 5.9 ± 1.4 years (Table 3). All 40 implants survived. However, three biological complications occurred (purulence (2); probing depth 6 mm associated with bleeding and pain on palpation (1)) which could successfully be treated. HAC survival was 97.5%. Over the observation period, one crown fracture was observed after 1.9 years, necessitating a refabrication of the restoration. No further technical or biological complications were noted.

FIPS scores were not normally distributed. Mean FIPS values were "interproximal" 1.78 (±0.48) points, "occlusion" 1.88 (±0.33) points, "design" 1.73 (±0.55) points, "mucosa" 1.80 (±0.41), and "bone" 1.50 (±0.51) points. The overall average FIPS score was 8.69 (±1.12) points (Table 4, Figure. 3).

DISCUSSION

Contemporary implant-supported prosthetics benefit from computer-aided workflows and advanced materials. The use of HACs, for example, consisting of a titanium base and an all-ceramic restoration with suitable material properties, appears to be useful to optimize the efficiency of the treatment and the overall result of the prosthetic restoration over more than 5.9 years.

This retrospective investigation examined the clinical outcomes of monolithic HACs by means of the Functional Implant Prosthodontic Score (FIPS)[39] that presented an overall score of 8.69 points out of 10 and a low SD of only 1.12 and, thus, indicates a successful clinical treatment outcome in a highly standardized protocol. Joda et al., who introduced the FIPS score, calculated a total score of 7.7 ± 1.0 points out of 10 in 50 lateral screw-retained monolithic SICs bonded to titanium abutments on soft tissue level implants after 2 years.[40] In another clinical trial, the same authors observed cemented CAD-CAM SICs over 5 years and found a total score of 8.2 ± 1.0 out of 10 for the FIPS, comparable to the present results.[38] Ferrari et al. found similar 8.6 ± 1.1 points for single-implant restorations on different implants in the posterior region after 1 year.[43] These comparisons, along with the high survival and success rates found in the present study, suggest that all hypotheses can be confirmed.

The FIPS method seems to be a very suitable tool and an objective and reliable evaluation instrument for the assessment of fixed implant restorations in follow-up examinations like the present one.[38–43] Radiographs in the present study were performed using a standardized right-angle technique, but without the use of an individual radiographic index. A statistical evaluation of the measured bone resorption was therefore not performed. However, the assessment of bone resorption as defined in the FIPS seemed appropriate and allows comparability with other studies that used a similar methodology. Moreover, the assessment of the radiographs of the HACs studied indicates that very little marginal bone resorption processes occurred during the observation period.

Lithium disilicate—as well as zirconia ceramic—exhibit favorable mechanical properties, appealing esthetics, and surface characteristics that are biologically suitable for transmucosal implant components and prosthodontic restorations.[28–30] Since one-piece ceramic abutments are prone to fracture at the implant-abutment interface[24] or can even wear and damage the titanium implant,[23] the application of titanium base CAD-CAM abutment has become widespread standard practice. The adhesive bonding between ceramic restorative materials and the titanium bases has demonstrated its high reliability.[22]

Other researchers have addressed the issue of CAD-CAM fabricated monolithic lithium disilicate HACs before. However, long-term studies of more than 5 years are sparse. Pjeturrson et al. reported an estimated annual failure rate for SICs made from monolithic-reinforced glass-ceramics of 0.60%, generated from data with a mean follow-up time of 2.6 years. Nevertheless, the results of cemented and screw-retained SICs as well as pressed and CAD-CAM fabricated SICs were not distinguished in one group.[6] Although the failure rates are comparable to those of the present study, a direct comparison of the data is difficult.

Teichmann et al. investigated the survival and complication rates of 17 Lithium disilicate (IPS Empress 2) SICs over 13.3 (± 2.3) years and found high survival (93.8%) and low chipping (5.9%) rates.[15] However, since the restorations were cemented crowns with a lithium disilicate framework layered with a veneering ceramic, the results are not readily transferable either.

Monolithic lithium disilicate SICs versus trans-occlusal screw-retained monolithic zirconia SICs were compared by de Angelis et al. over a follow-up period of 3 years. All crowns were fabricated in a complete digital protocol. The authors noted a survival of 100% with only minor technical

TABLE 2 The modified Functional Implant Prosthetic Score (FIPS) with five defined variables “interproximal”, “occlusion”, “design”, “mucosa”, and “bone”.

Variables	0	1	2
Interproximal: Contacts and papillae*	Major discrepancy (2× incomplete)	Minor discrepancy (1× complete)	No discrepancy (2× complete)
Occlusion: Static and dynamic	Major discrepancy (supra-contact)	Minor discrepancy (infra-contact)	No discrepancy
Design: Contour and color	Major discrepancy (contour)	Minor discrepancy (color)	No discrepancy
Mucosa: Quality and quantity	Non-keratinized Non-attached	Non-keratinized Attached	Keratinized Attached
Bone: X-ray	Radiographic bone loss (> 1.5 mm)	Radiographic bone loss (< 1.5 mm)	Radiographic bone loss not measurable
	Σ Score	Σ Score	Σ Score

*If there was only one adjacent tooth, the missing contact was defined as “complete”.

TABLE 3 Experimental setup and characteristics of the participants.

Parameters of study participants								
Gender			Female: 11				Male: 14	
Jaw			Maxilla: 15				Mandible: 25	
Observation period (years)		Minimum: 3.7		Mean (±SD): 5.9 (±1.4)			Maximum: 9.0	
Age at SIC placement (years)		Minimum: 29		Mean (±SD): 63.6 (±12.5)			Maximum: 79	
Implant system (*n*)		Camlog (19)		Straumann (18)			Zimmer Biomet (3)	
Implant position (*n*)			Premolar (18)				Molar (22)	
Implant diameter (*n*)	3.3 (1)	3.5 (1)	3.8 (4)	4.1 (17)	4.3 (14)	4.7 (1)	4.8 (1)	5.0 (1)
Healing method			Submerged: 40				Non-submerged: 0	

TABLE 4 Descriptive statistics of FIPS score.

Score	Mdn	IQR	Mean	SD	Minimum	Maximum
Interproximal	2	0	1.78	0.48	0	2
Occlusion	2	0	1.88	0.33	1	2
Design	2	0	1.73	0.55	0	1
Mucosa	2	0	1.80	0.41	1	2
Bone	1.5	1	1.50	0.51	1	2
Total	9	2	8.69	1.12	6	10

Abbreviations: Mdn, median; IQR, interquartile range; SD, standard deviation; Min, minimum; Max, maximum

complications and deduced from their findings that monolithic lithium disilicate and zirconia screw-retained single crowns fabricated using a fully digital workflow are reliable restorative options for posterior single implants.[16]

Pitta et al. examined different monolithic SICs supported by titanium bases and concluded from their observations that HACs made of lithium disilicate can be an alternative to PFM-based restorations, while zirconia and a tested hybrid material could not be recommended due to their inferior bonding capabilities and mechanical characteristics.[17]

Wolfart et al. investigated the frequency of biological and technical complications in cemented versus screw-retained monolithic lithium disilicate implant-supported posterior single crowns after 12 and 24 months. They found mucositis in 14.2% of the screw-retained and moderate bone loss, thus comparable results to the present study; however, within a considerably shorter period. In contrast to the present study, they noted a worsening in the quality of occlusal and proximal contact points.[18]

Limitations of the study are the restricted sample size, an observation period that can still be extended, and the retrospective and monocentric nature of the present survey. The lack of a comparison group is also a drawback, however of secondary importance to the intended results of the study.

Concerning the mode of fixation, that is, screw-retaining or cementing SICs, it may be stated that there is no evidence that one is clearly advantageous over the other. However, cemented reconstructions exhibit more serious biological complications (implant loss, bone loss >2 mm), whereas screw-retained reconstructions exhibited more technical problems.[26] The monolithic manufacture of screw-retained implant single crowns mounted to titanium bases, according to recent research by Camatta et al., also substantially contributes to the fracture strength of the crown-abutment-implant complex. This, in turn, might enhance the long-term prognosis compared to cemented restorations.[25] For these reasons, screw-retaining reconstructions might seem, nonetheless, to be preferable from a clinician's point of view.[25,26]

The digital approach helps streamline the laboratory and clinical protocol and enhance qualitymanagement through standardization.[34] In addition, a CAD-CAM fabricated monolithic crown can be easily restored after a fracture or loss based on the stored data, with or without modifications, and in virtually any place.[2] Screw-retained HACs can be considered advantageous not only in terms of workflow efficiency, but also because one can easily achieve predictable retention and, if needed, ease of retrieval. It moreover avoids the potential for biological complications associated with cement residues.[27]

Monolithic zirconia could also be a feasible treatment option for the manufacture of HACs, given that modern zirconia materials offer improved optical properties,[33] superior biocompatibility,[30] and likewise very efficient workability. However, there is evidence that the use of monolithic zirconia could shift the weakest point to the titanium base or, much more detrimental under extreme loading, to the implant itself.[11,12] A scientific evaluation of this issue under clinical conditions is needed.

Novel hybrid materials with advanced characteristics and features, such as resin matrix ceramics (RMC), might make a useful contribution to single-implant restorations.[10,13,20] Invivo data show a significantly higher failure rate of RMC-mounted SCs, however, clinical studies are rare.[6,14]

Given the aforementioned facts and based on the results of the present study, lithium disilicate ceramics should be considered as a monolithic restorative material for HACs.

CONCLUSION

The observations from this study—within its limitations—clearly suggest that CAD-CAM fabrication of screw-retained hybrid abutment crowns made of monolithic lithium disilicate facilitates an efficient workflow, but HACs also show excellent success rates—even over a longer clinical observation period.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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