Fit of CAD/CAM Implant Frameworks: A Comprehensive Review

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Computer-aided design and computer-aided manufacturing (CAD/CAM) is a strongly emerging prosthesis fabrication method for implant dentistry. Currently, CAD/CAM allows the construction of implant frameworks from different materials. This review evaluates the literature pertaining to the precision fit of fixed implant frameworks fabricated by CAD/CAM. Following a comprehensive electronic search through PubMed (MEDLINE), 14 relevant articles were identified. The results indicate that the precision fit of CAD/CAM frameworks exceeded the fit of the 1-piece cast frameworks and laser-welded frameworks. A similar fit was observed for CAD/CAM frameworks and bonding of the framework body to prefabricated cylinders. The influence of CAD/CAM materials on the fit of a framework is minimal.

Key Words: implant framework fit, misfit, titanium, zirconia, distortion

INTRODUCTION

The passive fit of an implant framework is defined as the simultaneous and even contact of all the fitting surfaces, without the development of strains prior to functional loading.[1,2] Obtaining a passive fit between the implant framework and the infrastructure is to minimize biologic and mechanical complications.[1,3] In light of the available evidence, this correlation is difficult to assume, as an inevitable degree of inaccuracy would always be present. Further, the clinical approaches to assessing the implant framework fit are crude and only detect gross misfits.[2] On these bases, some authors have argued against the importance of passive fit, and have assumed that well-controlled fabrication techniques are sufficient in providing a long-term successful implant treatment.[4] Still, until clear guidelines are formulated regarding the acceptable level of implant framework fit, together with a method of confirmation, it is crucial to aim for the best implant framework fit to minimize strain and gap formation.

In order to enhance implant framework fit, several processing technologies have been proposed. In general, 2 categories of processing technologies were identified: (1) the addition of a fit refinement step, or (2) the elimination of certain fabrication steps.[5] Included in the first category are sectioning and soldering/laser welding, spark erosion, and bonding of the framework body to prefabricated cylinders. The second category includes computer-aided design and computer-aided manufacturing (CAD/CAM). In modern dentistry, CAD/CAM technology is heavily used for tooth-supported and implant-supported prostheses. The proposed advantages of CAD/CAM are durability, predictability, and accuracy.[6] Furthermore, CAD/CAM is the only means of producing dental restorations constructed from high strength ceramics, such as zirconia. Given that well-engineered and accurate frameworks can be predictably produced by CAD/CAM, it is possible to move from conventional one-piece casting of highly expensive noble metal alloys. Subsequently, the cost efficiency of the implant treatment will markedly improve.

For tooth-supported fixed partial prostheses, there is a lack of compelling evidence supporting the superiority of CAD/CAM restoration fit over restorations fabricated from conventional fabrication techniques. In fact, earlier studies revealed an inferior fit of CAD/CAM restorations on teeth when

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Table 1
Inclusion criteria
Peer-reviewed journal article
English language publication
Control group is present
Assessing the fit of screw-retained or cement-retained framework
Complete or partial prosthesis framework
CAD/CAM is applied as framework fabrication method

*CAD/CAM indicates computer-aided design/computer-aided manufacturing.

compared to conventional fabrication methods.[7,8] Nevertheless, more recent studies observed a progressively improving outcome of CAD/CAM restoration fit.[9,10] CAD/CAM was subsequently applied to construct implant prosthesis frameworks, with variable span lengths and materials. The purpose of this review is to scrutinize the literature on the effect of CAD/CAM processing, and the effect of materials on the final fit of the implant framework. The null hypotheses are that CAD/CAM does not produce implant frameworks with better fit than other techniques, and there is no effect of altering CAD/CAM materials.

Materials and Methods

An electronic search of the English language literature was performed through PubMed (MEDLINE) with the aid of Boolean operator. The following key words were combined: "oral," "dental," "implant," "framework," "fit," "accuracy," "gap," fitting surface," "bridge," "fixed prosthesis," "computer-numeric-controlled", "computer-aided design," and "computer-aided manufacture." No publication year limit was applied. The electronic search aimed to obtain all the in vitro studies concerning the fit of implant fixed prosthesis frameworks fabricated by CAD/CAM. The search was completed in April 2012 and was limited to peer-reviewed articles that contained all or part of the key words in their titles. Article selection was conducted in 3 stages. Initially, the articles were selected according to the relevance of the title. This was followed by screening the abstract and excluding the irrelevant articles. Subsequently, a full text analysis of the remaining articles was conducted. This was followed by a full text review of each article, and cross-matching against the predefined inclusion criteria (Table 1). Additionally, the electronic search was complemented by manual searching through all the volumes of the following journals: *Clinical Implant Dentistry and Related Research*, *Clinical Oral Implants Research*, *International Journal of Oral and Maxillofacial Implants*, *Implant Dentistry*, *Journal of Oral Implantology*, *International Journal of Prosthodontics*, *Journal of Prosthetic Dentistry*, *Journal of Prosthodontics*, *Journal of Prosthodontic Research*, *Journal of Oral Rehabilitation*, *International Journal of Periodontics and Restorative Dentistry*, and *Quintessence International*. Furthermore, the reference lists of the selected articles were assessed for possible inclusion.

Results

Study search

Initially, 303 articles were retrieved by the electronic search. After analysis of the titles, 272 articles were excluded. Screening the abstracts excluded 14 articles, leaving 17 articles suitable for full-text analysis. Following the application of the inclusion criteria, 13 articles were selected. Manual searching and reviewing reference lists in the selected articles revealed an additional article suitable for inclusion. Therefore, a total of 14 articles were considered for this review. From the selected articles, the relevant information was extracted. Wherever identified, the vertical fit values were recorded.

Description of studies

The selected studies revealed a variation in implant and abutment systems. Moreover, there are significant differences in the methods of implant framework fit assessment. The approaches applied to assess framework fit included the following:

Dimensional Measurements

These measurements aim to quantify the degree of misfit or distortion between the framework and the infrastructure. The following dimensional measurements were applied by the studies:

- Microscopic measurement: assesses the actual gap or in conjunction with replica application, where the thickness of the light-body impression of the fitting interface was measured. The microscopic measurement can measure the actual gap between the framework and the infrastructure.

TABLE 2 Definitions of fit assessment conditions used for this review	
Condition	Definition
Final fit	Gap formed between the framework and the implant/abutment when all the retaining screws are tightened
Passive fit	Gap formed between the framework and the implant/abutment when the distant screw is tightened
Vertical distortion	Gap formed between the framework and the implant/abutment when the framework is fitted without tightening the screws
Virtual fit	Vertical discrepancy resulted after superimposing the framework and implant/abutment image

- Photogrammetric technique: superimposes the framework images and the master model. Superimposing the images can only provide the virtual gap rather than the actual gap.
- Contact scanner: obtains 3-dimensional images of the framework and the master model, which can be superimposed. Similarly to the photogrammetric technique, the virtual gap can be measured.

The selected studies employed the dimensional measurements in different fit assessment conditions. This involved hand fitting the framework without tightening the retaining screws, tightening the most distant screw, tightening all the screws, or virtually superimposing the framework and working model images. Since significant variations in vertical gap values will result due to differences in experimental set-up, this review considers the different fit assessment conditions applied in each study. For the purpose of uniformity, each fit assessment condition is defined in Table 2.

Modelling Techniques

These techniques are based on a biomechanical model that aims to evaluate the effect of misfit. The studies only used strain gauge analysis which involves applying strain gauges on the model around the implants to determine the strain development as a result of fitting the framework. Less strain indicates a better framework fit.

Studies Summary

The included studies are summarized in Table 3. Twelve studies compared the fit of CAD/CAM frameworks to frameworks produced by other fabrication techniques. The other fabrication techniques can be summarized as follows:

- One-piece casting: constructs the framework bythe lost wax technique without further modifications.[11–21]
- Laser welding: used as a fit refinement treatment in the form of vertical laser welding or horizontal laser welding. Vertical laser welding involves the sectioning and reconnection of the framework, or connection of several prefabricated framework pieces.[17] Horizontal laser welding is based on sectioning of the framework fitting surfaces and the connection of prefabricated cylinders.[17,22] Horizontal laser welding is also commonly referred to as the Cresco Precision method.
- Framework bonding to prefabricated cylinders: constructs the framework body with space to accommodate a prefabricated cylinder and resin bonding material.[19]
- Copy/milling: mills the framework from a copy of fabricated resin pattern. This method is applied to the ceramic framework.[9,20]

The CAD/CAM systems employed were Procera (Nobel Biocare, Göteborg, Sweden), CAM StructSURE (Biomet 3i, Palm Beach Gardens, Fla), and Etkon (Straumann, Waldenburg, Switzerland). One study compared different CAD/CAM manufacturers.[17] In relation to CAD/CAM material, the Procera system manufactured screw-retained frameworks from grade II commercially pure titanium, and presintered zirconia; while the CAM StructSURE manufactured screw-retained frameworks from titanium alloy. The Etkon system manufactured cement-retained frameworks from grade IV commercially pure titanium, cobalt-chromium alloy, postsintered zirconia, presintered zirconia, infiltrated alumina ceramic, infiltrated zirconia ceramic and fiber-reinforced resin. Two studies compared different CAD/CAM materials. One study compared the fit of titanium and presintered zirconia frameworks;[23] the other study compared the fit of titanium, cobalt-chromium, postsintered zirconia, presintered zirconia, infiltrated alumina ceramic, infiltrated zirconia ceramic, and fiber-reinforced resin.[19]

In relation to the prosthesis design, 9 studies[11–17,21,22] evaluated complete arch frameworks while 5 studies[9,18–20,23] evaluated 3-unit partial arch frameworks. All the studies that applied complete arch design used the screw retained design. Two of the partial framework studies applied the screw retained design,[18,23] and 3 of them used the cement retained design.[9,19,20]

The vertical fit of CAD/CAM frameworks ranged from 1 to 27 μm. There is an agreement between the studies that an inevitable level of inaccuracy exists regardless of the fabrication methodology and material. However, there is also an agreement that CAD/CAM provides a very accurate framework fit in comparison with other fabrication techniques.

In relation to complete arch frameworks, one study found an insignificant difference in the vertical misfit between titanium CAD/CAM frameworks and 1-piece cast frameworks from gold alloy.[14] On the contrary, 5 studies proved that CAD/CAM frameworks exhibited a better fit than 1-piece cast frameworks from gold alloy.[12,13,15,16,21] Al Fadda et al showed that CAD/CAM frameworks had a better fit than 1-piece cast frameworks from silver-palladium alloy.[11] Torsello et al confirmed that the titanium CAD/CAM frameworks displayed a better fit than frameworks fabricated by titanium alloy 1-piece casting or vertical laser welding.[17] However, no significant difference was detected between titanium CAD/CAM frameworks and frameworks fabricated by titanium horizontal laser welding. This outcome opposes the study by Hjalmarsson et al, who found titanium CAD/CAM frameworks exhibited better fit than horizontal laser welding of titanium or cobalt-chromium alloys.[22] After comparing frameworks fabricated by Procera and CAM StructSURE, Torsello et al observed no significant difference in the fit.[17]

For the 3-unit partial arch frameworks, the screw-retained titanium CAD/CAM frameworks exhibited a better fit than one-piece cast frameworks from gold alloy.[18] In another study, Karl et al found a better fit for the cement-retained zirconia CAD/CAM frameworks when compared to the zirconia copy/milled frameworks or cast gold alloy frameworks.[20] An additional study also confirmed the superiority of the zirconia CAD/CAM frameworks over the zirconia copy/milled frameworks.[9] Karl and Taylor showed that titanium, zirconia and cobalt-chromium alloy CAD/CAM frameworks had a better fit than cement-retained or screw-retained cast frameworks from gold alloy.[19] However, the difference between CAD/CAM framework and frameworks constructed by bonding prefabricated cylinders to the framework body is minimal. In the same study, altering CAD/CAM material (titanium, cobalt-chromium alloy, postsintered zirconia, presintered zirconia, infiltrated alumina ceramic, infiltrated zirconia ceramic or fiber-reinforced resin) for cement-retained frameworks construction had a minimal influence on the framework fit.[19] On the contrary, Abduo et al[23] found that Zirconia frameworks exhibited a slightly better fit than titanium frameworks when comparing screw-retained titanium and zirconia CAD/CAM frameworks.

Discussion

Although the implant-supported prosthesis has been widely fabricated for more than 3 decades, the significance of implant framework passive fit is not yet clear. The concept of passive fit implies that there be no gap or strain development while fitting the implant framework prior to functional loading.[1,2] The outcome of this review confirms that passive fit does not truly exist, and is not even possible with the available fabrication techniques. The biological studies reflect that the compensatory adaptation mechanism for the lack of passive fit is not necessarily associated with the greater biological complication of loss of osseointegration.[4,24] Still, clinicians should always aim for the best possible fit of implant frameworks until otherwise is proven. In addition, it is critical for the clinician and technician to consider a fabrication technique that is reliable, time efficient, and predictable in providing an accurate implant framework. The rest of the discussion will emphasize the influence of CAD/CAM application on framework fit and the implications of CAD/CAM materials.

CAD/CAM accuracy

After comparing CAD/CAM to other fabrication techniques, the consensus of all the included studies is that CAD/CAM is either superior or at least equivalent to the other techniques. This review illustrates the consistency of CAD/CAM in producing accurately fitting frameworks. Therefore, the null hypothesis that CAD/CAM produces an implant framework fit that is equivalent to other fabrication

TABLE 3

Characteristics of studies included in the review*

Study	Sample size	System	Material	Implant number	Span length	Implant system (Fit Level)
Jemt et al[14]	10	CAD/CAM (Procera)	Titanium	5	Complete arch	Branemark (abutment)
	10	One-piece casting	Gold alloy			
Ortorp et al[15]	20	CAD/CAM (Procera)	Titanium	5	Complete arch	Branemark (abutment)
	5	One-piece casting	Gold alloy			
Takahashi and Gunne[16]	14	CAD/CAM (Procera)	Titanium	2–6	Complete arch	NA (abutment)
	5	One-piece casting	Gold alloy	3–7		
Al-Fadda et al[11]	9	CAD/CAM (Procera)	Titanium	5	Complete arch	Branemark (abutment)
	9	One-piece casting	Silver-palladium alloy			
Torsello et al[17]	3	CAD/CAM (Procera)	Titanium	5–9	Complete arch	Straumann (implant)
	3	CAD/CAM (CAM StructSURE)	Titanium alloy			Straumann (implant)
	3	One-piece-casting	Titanium alloy			Straumann (abutment)
	3	Vertical laser welding	Titanium alloy			Straumann (abutment)
	3	Horizontal laser welding	Titanium alloy			Straumann (abutment)
Almasri et al[12]	5	CAD/CAM (CAM StructSURE)	Titanium alloy	5	Complete arch	Biomet 3i (implant)
		One-piece casting	Gold alloy			
Drago et al[13]	15	CAD/CAM (CAM StructSURE)	Titanium alloy	5	Complete arch	Biomet 3i (implant)
		One-piece casting	Gold alloy			
Hjalmarsson et al[22]	5	CAD/CAM (Procera)	Titanium	5	Complete arch	Branemark (implant)
	10	Horizontal laser welding	Titanium			
	10	Horizontal laser welding	Cobalt-chromium alloy			
Abduo et al[23]	5	CAD/CAM (Procera)	Titanium	2	3-unit	Branemark (implant)
		CAD/CAM (Procera)	Pre-sintered zirconia			
Karl et al[20]	10	CAD/CAM (Etkon)	Pre-sintered zirconia	2	3-unit	Straumann (abutment)
		Copy/mill	Pre-sintered zirconia			
		One-piece casting	Gold alloy			
Karl and Taylor[19]	10	CAD/CAM (Etkon)	Titanium	2	3-unit	Straumann (abutment)
		CAD/CAM (Etkon)	Cobalt-chromium alloy			
		CAD/CAM (Etkon)	Post-sintered zirconia			
		CAD/CAM (Etkon)	Pre-sintered zirconia			
		CAD/CAM (Etkon)	Infiltrated alumina			
		CAD/CAM (Etkon)	Infiltrated zirconia			
		CAD/CAM (Etkon)	Fibre-reinforced resin			
		One-piece casting	Gold alloy			
		One-piece casting	Gold alloy			
		Framework bonding to prefabricated cylinders	Gold alloy			
Karl et al[9]	10	CAD/CAM (Etkon)	Pre-sintered zirconia	2	3-unit	Straumann (implant)
		Copy/mill	Pre-sintered zirconia			
Karl and Holst[18]	10	CAD/CAM (Procera)	Titanium	2	3-unit	Straumann (implant)
		One-piece casting	Gold alloy			Straumann (abutment)
Sierraalta et al[21]	10	CAD/CAM (Procera)	Titanium	6	Complete arch	Nobel Replace (implant)
	5	One-piece casting	Gold alloy			

*CAD/CAM indicates computer-aided design/computer-aided manufacturing; NA, not available.

techniques is rejected. It has been established that each fabrication step introduces further inaccuracies in the final framework, ranging from impression, cast pouring, wax-up, investing, metal casting, polishing, and veneer application.[3] The current CAD/CAM systems are distinguished by bypassing the waxing, investing, casting, and polishing steps. This implies that the reason behind the high

Table 3

Extended

Retention mechanism	Assessment method	Fit condition	Vertical fit value	Main findings
Screw	Photogrammetric	Virtual fit	11.0 10	Insignificant difference between the different fabrication methods and materials
Screw	Contact scanner	Virtual fit	1.0 8.0	Significantly better fit with titanium CAD/CAM frameworks
Screw	Microscopic examination of replica (X30)	Vertical distortion	26.9 46.8	Significantly better fit with titanium CAD/CAM frameworks
Screw	Contact scanner	Virtual fit	13.3 59.2	Significantly better fit with titanium CAD/CAM frameworks
Screw Screw Cement Cement Screw	Microscopic examination (X100)	Vertical distortion	21 27 78 33 18	Insignificant difference between the different titanium CAD/CAM manufacturers Insignificant difference between CAD/CAM and horizontal laser welding techniques One-piece casting of titanium frameworks produced significantly poorly fitting frameworks
Screw	Contact scanner	Volumetric misfit in passive fit and virtual fit conditions		Significantly better fit with titanium CAD/CAM frameworks
Screw	Contact scanner	Volumetric misfit in passive fit and virtual fit conditions		Significantly better fit with titanium CAD/CAM frameworks
Screw	Contact scanner	Virtual fit	3.0 9.0 6.0	Significantly better fit with titanium CAD/CAM frameworks
Screw	Microscopic examination (X50)Strain gauge analysis	Final fit Passive fit Final fit Passive fit	3.6 13.6 3.7 5.5	Significantly better passive fit with zirconia CAD/CAM frameworks Insignificant difference in vertical fit between the different CAD/CAM materials
Cement	Strain gauge analysis	NA	NA	Significant difference between all the groups The best fit was for zirconia CAD/CAM followed by zirconia copy/mill
Cement Cement Cement Cement Cement Cement Cement Cement Screw Screw	Strain gauge analysis	NA	NA	Insignificant difference between different CAD/CAM materials The best fit was obtained by CAD/CAM and framework bonding to prefabricated cylinders Insignificant difference between CAD/CAM and framework bonding to prefabricated cylinders One-piece casting produced significantly poorly fitting screw-retained frameworks
Cement Cement	Strain gauge analysis	NA	NA	Slightly (insignificant) better fit for zirconia CAD/CAM than zirconia copy/mill
Screw	Strain gauge analysis	NA	NA	Significantly better fit with titanium CAD/CAM frameworks
Screw	Contact scanner	Virtual fit	3.7 21	Significantly better fit with titanium CAD/CAM frameworks

accuracy of the CAD/CAM fabrication technique can be due to the omission of several error-introducing fabrication steps. For the 1-piece casting technique, inaccuracies might manifest due to numerous steps, and the expansion and contraction associated with a significant temperature fluctuation.[3,14] Although the CAD/CAM fabrication method eliminates several steps, it introduces other steps such as scanning, software modelling, and framework milling. These steps were confirmed contributors to inaccuracies of restorations fabricated on prepared teeth.[7,8] Following abutment tooth preparation, variations in tooth preparations are inevitable. This increases the reliance on the scanning system to capture all the surface minor details, while generating accurate virtual images of the prepared abutment tooth. At the modelling stage, margin placement and restoration contour are subjected to human errors and were proven to suffer from more discrepancies than cast restorations.[8] Furthermore, the milling procedure accuracy is dictated by the diameter of the smallest bur.[25] Surface details less than the diameter of the smallest milling bur will not be faithfully produced. Nevertheless, implant framework CAD/CAM accuracy is superior to framework casting. The difference of CAD/CAM outcomes between prepared teeth and implant/abutment infrastructures can be attributed to 2 main reasons. The first is the uniformity of the machined surfaces of the implant or the abutment: the well-defined surfaces and known angles enhance the acuity of the scanning step and subsequent determination of the framework fitting surface extension.[26] The other reason is that the precise dimensions of the machined implant and abutment are integrated within the CAD software. Subsequently, the scanning system primarily registers the location and the orientation of the implants rather than recording the minor surface details. Since the framework fitting surface of a multi-unit implant framework is composed of nonengaging cylinders, the milling procedures do not involve producing minor details or sharp corners.

A relatively similar framework fit can be obtained with horizontal laser welding[17] and bonding prefabricated cylinders to the framework body.[19] However, these methods are very technique sensitive and demand advanced technical skills to produce a reliable fit. This might explain the variation of the fit of the frameworks produced by horizontal laser welding.[17,22] Additionally, more technical time is required with these techniques compared to any other fabrication technique. On the other hand, CAD/CAM has the advantage of being much less technique sensitive and time-demanding while maintaining a trivial reliance on human work in comparison to other fabrication techniques.[15,27] All of these points make CAD/CAM systems user friendly. In addition, the mechanical durability is superior as the CAD/CAM framework is produced from the milled blank as a single piece with minimal flaws and deficiencies.[6] Laser-welded frameworks were shown to exhibit a greater fracture rate when compared to 1-piece gold alloy cast frameworks: the framework fractures were associated with the laser-welded junction composing weak spots.[28] However, the CAD/CAM titanium frameworks were shown to be equivalent to the 1-piece gold alloy cast frameworks.[29]

Following the comparison of the vertical gap for partial and complete arch CAD/CAM frameworks, it appears that the values did not differ markedly,[21,23] indicating that the span length is not necessarily a contributing factor to framework distortion. A different outcome is observed for 1-piece cast frameworks, where the potential of distortion is exacerbated with a longer span and incorporation of pattern curvature.[14] However, this assumption still requires validation by further studies, as no single study evaluated the effect of span length.

Since the CAD/CAM vertical gap ranged from 1 to 27 μm, one could assume that the fit values are comparable to values obtained from the fitting abutment on the implant.[30] However, it should be maintained that the included studies are in vitro: the frameworks were constructed directly on the experimental model, eliminating steps from the clinical protocol, such as impression and cast pouring. These steps produced an accumulative vertical gap of up to 150 μm.[31,32] Therefore, the true misfit magnitude can be underestimated, and clinically, a greater misfit magnitude should be anticipated. Furthermore, this review considered the fit of implant frameworks prior to the veneering process, which can contribute to further framework distortion.[3,9]

Therefore, it appears that CAD/CAM can produce implant frameworks with at least equivalent fit to the best available framework fabrication methods. In addition, the simplicity and consistency of CAD/CAM outcome makes it a reliable method for framework fabrication.

CAD/CAM Material

Titanium was the first material produced by CAD/CAM for implant prosthesis frameworks. In a growing esthetically conscious society, there is a continuous demand for highly esthetic restorations. This led to the development of zirconia frameworks for implant prostheses. Zirconia has the advantages of an esthetic appearance, biocompatibility, limited plaque accumulation, and superior mechanical properties. The limited studies that compared milled implant titanium and zirconia frameworks revealed that both exhibited a comparable fit.[19,23] Therefore, the null hypothesis that altering CAD/CAM material has no influence on implant framework fit was accepted. Although zirconia and titanium implant frameworks can be produced by CAD/CAM, there is a profound difference between them. For titanium implant frameworks, titanium is milled from titanium blank with the aid of subtractive CNC machine. Zirconia can be produced by a similar system; however, 2 milling streams are available: soft machining of an oversized presintered blank or hard machining of a postsintered blank.[33] Soft machining involves sintering the oversized framework to attain its complete strength, which causes about 25–30% shrinkage of the whole workpiece. Therefore, these systems should compensate for this shrinkage in 3 dimensions.[33] Most of the commercially available CAD/CAM systems apply the presintered milling due to easier milling and time efficiency.[33] In terms of framework fit on teeth, the studies showed conflicting outcomes regarding the superiority of presintered or postsintered zirconia milling.[10,34] After comparing cement-retained zirconia, titanium, and cobalt-chromium CAD/CAM frameworks on implants, Karl and Taylor reported a similar level of fit.[19] Furthermore, the outcomes of soft machining and hard machining of zirconia were comparable.[19] Therefore, it is evident that the CAD software is efficient in compensating for the shrinkage of implant zirconia framework after sintering.

The comparison of titanium and zirconia CAD/CAM screw-retained frameworks showed a slightly better fit for the zirconia frameworks.[23] The authors attributed this finding to the difficulties associated with milling titanium and the risk of "machining-induced distortions."[23] Milling titanium can cause machine vibrations and exert mechanical and thermal stresses on the framework, which can contribute to dimensional distortion. Moreover, the milling burs are subjected to a greater wear rate.[23,25] These problems are minimal for the case of soft machining of zirconia blank. However, since the 2 material frameworks produced a vertical gap of less than 15 μm, the clinical significance of this finding is most likely insignificant.

Since the available evidence for zirconia framework is only relevant for short-span fixed dental prostheses, the extrapolation of the fit values for complete arch prostheses frameworks should be confirmed by further investigations. A systematic review on the fit of zirconia frameworks on teeth found that the longer and curved zirconia frameworks are subjected to a greater sintering distortion than the shorter and straight frameworks.[7]

Although an accurate fit of zirconia frameworks is possible according to the minimal available evidence, it is critical that its recommendations should be based on the clinical application. According pilot investigations that assessed the clinical performance of zirconia frameworks for partial and complete arch fixed prostheses, all the frameworks had an acceptable fit and none required remaking.[35,36] However the percentage of veneering ceramic failure was shown to be very high (50–90% of patients).[35,36] The authors recommended cautions prior to routine zirconia prostheses application.[35]

Conclusions

Within the limitations of this review, the following can be concluded:

(1) CAD/CAM is capable of producing implant frameworks with a precision of fit that surpasses the 1-piece casting and laser-welded frameworks. Reliability and consistency of the CAD/CAM framework fit was observed by the included studies. The accuracy of CAD/CAM is not influenced by the framework retention mechanism.
(2) Titanium and zirconia implant frameworks can be fabricated with a high level of accuracy with the aid of CAD/CAM. For complete arch and partial arch prostheses, producing titanium frameworks by CAD/CAM is reliable in providing an acceptable fit. However, the zirconia frameworks were confirmed to exhibit an accurate fit for partial arch prostheses only.

Abbreviation

CAD/CAM: computer-aided design/computer-aided manufacturing

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