THE JOURNAL OF PROSTHETIC DENTISTRY

SYSTEMATIC REVIEW

Marginal adaptation and CAD-CAM technology: A systematic review of restorative material and fabrication techniques

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ABSTRACT

Statement of problem. The comparative assessment of computer-aided design and computer-aided manufacturing (CAD-CAM) technology and other fabrication techniques pertaining to marginal adaptation should be documented. Limited evidence exists on the effect of restorative material on the performance of a CAD-CAM system relative to marginal adaptation.

Purpose. The purpose of this systematic review was to investigate whether the marginal adaptation of CAD-CAM single crowns, fixed dental prostheses, and implant-retained fixed dental prostheses or their infrastructures differs from that obtained by other fabrication techniques using a similar restorative material and whether it depends on the type of restorative material.

Material and methods. An electronic search of English-language literature published between January 1, 2000, and June 30, 2016, was conducted of the Medline/PubMed database.

Results. Of the 55 included comparative studies, 28 compared CAD-CAM technology with conventional fabrication techniques, 12 contrasted CAD-CAM technology and copy milling, 4 compared CAD-CAM milling with direct metal laser sintering (DMLS), and 22 investigated the performance of a CAD-CAM system regarding marginal adaptation in restorations/infrastructures produced with different restorative materials.

Conclusions. Most of the CAD-CAM restorations/infrastructures were within the clinically acceptable marginal discrepancy (MD) range. The performance of a CAD-CAM system relative to marginal adaptation is influenced by the restorative material. Compared with CAD-CAM, most of the heat-pressed lithium disilicate crowns displayed equal or smaller MD values. Slip-casting crowns exhibited similar or better marginal accuracy than those fabricated with CAD-CAM. Cobalt-chromium and titanium implant infrastructures produced using a CAD-CAM system elicited smaller MD values than zirconia. The majority of cobalt-chromium restorations/infrastructures produced by DMLS displayed better marginal accuracy than those fabricated with the casting technique. Compared with copy milling, the majority of zirconia restorations/infrastructures produced by CAD-CAM milling exhibited better marginal adaptation. No clear conclusions can be drawn about the superiority of CAD-CAM milling over the casting technique and DMLS regarding marginal adaptation. (J Prosthet Dent 2018;119:545-51)

A successful dental restoration should have 4 distinct properties: marginal adaptation, biocompatibility, esthetics, and mechanical strength.[1] The presence of marginal discrepancies can increase plaque accumulation, alter the distribution of microflora, and contribute to a higher risk of caries in the abutment teeth.[2-5] In implant dentistry, passive fit ensures both mechanical and biological equilibrium and eliminates overloading of the abutment-screw-implant assembly and the supporting bone.[6-8]

On the basis of the available scientific evidence, no consensus exists on the maximum clinically acceptable marginal discrepancy (MD), with reported values varying between 50 and 200 μm.[9-11] Increased MD values reduce the fracture resistance of the crown and the veneering porcelain.[12-15] Four different terms have been used to define the marginal accuracy or adaptation of fixed dental restorations: marginal gap (MG), absolute MD (AMD), vertical MD, and horizontal MD.[16]

Because the conventional fabrication process involves multiple materials as well as clinical and laboratory stages, marginal inaccuracies are unavoidable.[17-22] The development of computer-aided design and computer-aided manufacturing (CAD-CAM) technology has been dramatic. The CAD-CAM production process uses either direct or indirect digitalization and enables the design, analysis, and (additive or subtractive) manufacturing of

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Clinical Implications

CAD-CAM technology offers dental practitioners the ability to produce well-fitting dental prostheses. Conventional fabrication techniques are still considered effective and reliable for the fabrication of precise dental prostheses.

restorations with a computer.[23] Because the clinical goal for a cemented restoration is an MD value ranging 25 to 40 μm,[24] CAD-CAM manufacturers aim to produce dental restorations within these values. In fixed prosthodontics, the comparison between CAD-CAM technology and traditional fabrication processes with respect to marginal adaptation has been extensively studied.[25-62] According to Boitelle et al,[63] a reliable CAD-CAM system should be able to machine different restorative materials appropriately and precisely for the production of high-quality restorations. The range of restorative material properties has been reported to influence the marginal adaptation of CAD-CAM restorations.[64-81]

In a systematic review, Boitelle et al[63] reported that CAD-CAM technology provides dental prostheses with MD values less than 80 μm. Additionally, dental restorations manufactured by the digital scanning technique presented statistically similar MD values compared with those produced by conventional impression-making procedures.[82,83] Abduo[84] concluded that CAD-CAM implant frameworks displayed better precision fit compared with those manufactured by a conventional casting technique (CCT) or laser welding process.

Therefore, the purpose of this systematic review was to investigate whether the marginal adaptation of single crowns (SCs), fixed dental prostheses (FDPs), implant-retained fixed dental prostheses (IRFDPs), or their infrastructures, as manufactured by a specific CAD-CAM system, depends on the type of restorative material or differs from that obtained by other fabrication techniques using a similar restorative material.

MATERIAL AND METHODS

This systematic review was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) statement and the PICO(S) approach (Patient or Population, Intervention, Control or Comparison, Outcome, and Study types).[85,86] Two main PICO questions were formulated: In patients (P) scheduled to be fitted with SCs/FDPs/IRFDPs, does CAD-CAM technology (I) compared with other fabrication techniques (C) render dental restorations with better marginal adaptation (O) when the restorative material is similar? In patients (P) scheduled to be fitted with SCs/FDPs/IRFDPs produced by specific CAD-CAM system (I), does the marginal adaptation (O) depend on the type (C) of the restorative material?

To address the first main PICO question, only comparative studies contrasting the marginal adaptation of SCs/FDP/IRFDPs or their infrastructures produced using CAD-CAM technology (subtractive or additive) with those produced using alternative fabrication techniques were eligible for inclusion. The range of fabrication techniques encompassed conventional techniques, including CCT, heat-press (HP), and slip-casting (SLC), CAD-CAM milling technology, direct metal laser sintering (DMLS), and copy-milling (CM) manufacturing processes. Comparative studies investigating the performance of a specific CAD-CAM system with regard to marginal adaptation in prosthetic restorations and infrastructures produced with different materials were also potentially relevant to the second PICO question.

To identify all information relevant to this review study, the researchers (S.P., A.P.) followed a 2-stage literature search strategy. First, an intensive electronic search of English-language literature published between January 1, 2000, and June 30, 2016, was conducted of the Medline/PubMed database. A list of keywords was generated and used in different combinations as follows: "CAD-CAM," "CAM," "marginal adaptation," "marginal fit," "marginal gap," "accuracy," "discrepancy," "precision," "passive fit," "casting," "heat-press," "slip-casting," "laser sintering," and "copy-milling." Both authors (S.P., A.P.) verified the eligibility of the potentially relevant articles and independently screened titles and abstracts to evaluate the articles for full-text reading. When disagreement occurred, titles were used to obtain full texts, and consensus was achieved after discussion. In the second round of the search, only studies meeting specific inclusion criteria were selected. Finally, to supplement the electronic search, a hand search was conducted by considering entries in the reference lists of the selected articles, and articles not yet included were then added (Table 1).

The outcome parameters of the systematic review involved marginal adaptation assessment by using quantitative measurement of MG/MD/AMD or marginal fit in SCs/FDPs/IRFDPs or their infrastructures produced by CAD-CAM technology and alternative manufacturing techniques. In the case of randomized controlled clinical trials (RCTs) or controlled clinical trials, the risk of bias was assessed with the Cochrane Collaboration Tool.[87] The recorded data items for each included study were the author names, the year of publication, the type of study, the sample size, the type of dental prosthesis, the alternative fabrication process, the CAD-CAM and restorative material trade names, the applied MD measurement

Table 1. Inclusion and exclusion criteria

Inclusion	Exclusion
• English language	• Unrelated to the PICO questions studies
• Comparative studies either in vivo, in vitro, or ex vivo	• Reviews
• Studies answering the PICO questions	• Case reports
• Clear report of CAD-CAM system trade name	• Expert opinions
• Clear report of measurement technique	• Animal studies
• Clear report of trade name of restorative materials	• No clear report of CAD-CAM system trade name
• Clear report of MG, MD, marginal internal gap, or AMD values	• No clear report of measurement technique
	• No clear report of trade name of restorative materials
	• Qualitative assessment of marginal adaptation

PICO, Patient or Population, Intervention, Control or Comparison, Outcome; CAD-CAM, computer-aided design and computer-aided manufacturing; MG, marginal gap; MD, marginal discrepancy; AMD, absolute marginal discrepancy.

technique, and the results with respect to the MD, MG, or AMD mean and/or standard deviation values.

RESULTS

The electronic and manual searches initially yielded 290 records that were considered relevant. A detailed screening of both titles and abstracts followed, resulting in the full-text reading of 70 articles. Eventually, 55 articles[25-62,65-81] satisfied the defined inclusion criteria, including 2 RCTs,[42,58] 2 in vivo[37,79] and 51 in vitro[25-36,38-41,43-57,59-62,65-78,80,81] comparative studies. With regard to the first PICO question, 28 studies compared CAD-CAM technology with conventional techniques, including the CCT,[30,34-38,46,47,50,53,57,58,59,60,61,62] HP[25,39,40,42,49,51,52], and SLC techniques,[41,43-45] and the direct fabrication method for interim restorations.[54] Four studies[53,57,58,61] compared CAD-CAM milling with DMLS, and 12 studies[26-29,31-33,41,48,55,56,59] compared CAD-CAM technology with the CM process (Supplemental Table 1).

To answer the second PICO question, 21 in vitro[25,30,43,45,46,65-77,79-81] and 1 in vivo[78] comparative studies were identified (Supplemental Table 2). Among the CAD and/or CAM systems were E4D (Planmeca/E4D Technologies LLC),[39,51] 3Shape A/S Dental System,[36,50,53,57,61,62] Pro 50 (Cynovad),[60] DCS (DCS Dental AG),[60,66,73] Lava (3M ESPE),[31,39,56,74] CEREC (Dentsply Sirona),[42,51,54] Etkon (Etkon AG),[33] Ceramill (AmannGirrbach AG),[48,56,61] Biomain AB[53] CARES (Straumann GmbH),[71] CEREC 3,[55,65-77,79-81] Cercon (DeguDent),[26-29,32,40] Compartis (Degudent),[32] Celay (Mikrona),[41] DMG (Mori Seiki),[52] Kavo Everest (KaVo Dental GmbH),[38,47,60,68,72] Neoshape (Neodent),[30,46] Straumann gonyX (Straumann),[49] Yenadent D 30 (Yenadent),[58] Eosint M 270 (EOS GmbH),[57,58,61,62] CEREC inLab (Dentsply Sirona),[25,33,43-45,41,67,68,77,79,80] Procera (Nobel Biocare),[48,65,69,70,81] Zirkonzahn (Zirkonzahn GmbH),[29,31] Cercon Eye (Dentsply Sirona),[34,35] PM 100 Dental (Phenix Systems),[34,35] BEGO Medifacturing (BEGO Medical),[36,37,50,78] InEos Blue (Dentsply Sirona),[75,76] and CAM StructSURE (BIOMET 3i).[59]

Among the applied restorative materials were presintered yttria-stabilized tetragonal zirconia (Y-TZP),[25-33,43,45,46,48,55,65-72,74,79,81] fully sintered Y-TZP,[72,73] cobalt-chromium (CoCr) alloy,[30,34-37,46,50,53,57,58,61,62,71,74,78] poly(methylmethacrylate),[54,75,76] lithium disilicate,[25,39,40,42,49,51,52] glass-infiltrated alumina-based zirconia-reinforced ceramic,[43-45,66,67,77,79] titanium alloys,[38,47,59,60,65,69,70,72,73] leucite reinforced glass ceramic,[72] fiber-reinforced composite,[73] acrylate polymer,[75,76] alumina ceramic,[81] glass-infiltrated alumina ceramic,[41,77,80] feldspathic ceramic,[80] and high noble alloys.[78] The MD measurement techniques involved the direct-view technique with a stereomicroscope,[29,31,36-38,40,52,53,59,60,73,76,79] scanning electron microscopy,[25-28,30,34,35,43,44,46,55,69,70] or optical microscope,[33,65,68] the 3-dimensional laser scanner,[39] the cross-sectioning technique,[43,47,48,56] the weight technique,[43] the impression replica technique,[32,41,42,45,50,54,57,58,61,62,66,71,72,74,77,78,81] and computerized x-ray microtomography.[49,51,67,80] Finally, the overall quality of RCTs was rated as moderate because none of the studies involved blinding of the participants, prospective calculation of study size, or blind evaluation of the study end points (Table 2).

DISCUSSION

From the available evidence addressing the defined PICO questions of this systematic review, it was determined that the majority of dental restorations or infrastructures produced by CAD-CAM technology produced MD values within the clinically accepted range, namely up to 120 μm as proposed by McLean and von Fraunhofer.[9] With respect to the second PICO question, it was concluded that the performance of a specific CAD-CAM system in relation to marginal adaptation is influenced by the type of restorative material.

The existing scientific evidence does not allow clear conclusions to be drawn about the superiority of CAD-CAM milling technology over CCT with respect to marginal accuracy (Supplemental Table 1). Two in vitro studies demonstrated that, compared with CCT, the MD values in the NeoShape CoCr copings of 3-unit implant

Table 2. Assessment of risk of bias in included randomized controlled trials

	Selection Bias		Performance Bias		Detection Bias	Attrition Bias	Reporting Bias	
Study, year	**Random Sequence Generation**	**Allocation Concealment**	**Blinding of Participant**	**Blinding of Personnel**	**Blinding of Outcome Assessors**	**Data Integrity**	**Selective Report**	**Other Sources of Bias**
Akin et al, 2015[42]	Yes	Not clarified	No	Yes	Yes	Yes	No	No
	"Drawing lots after informed consents were granted"		"This randomized-controlled single-blinded (evaluator)"		"This randomized-controlled single-blinded (evaluator)"		"Kappa value for evaluator's reproducibility in measurement of marginal and internal adaptation was 0.72. Similarly, kappa value for the same evaluator's reproducibility in determining clinical evaluation scores was 0.74"	"The authors deny any conflicts of interest"
Tamac et al, 2014[58]	Yes	Not clarified	Not clarified	Yes	Yes	Yes	No	Not clarified
	"42 patients were randomly assigned to 1 of the metal-ceramic crown fabricating techniques, CAD-CAM milling system (CCM), DMLS, or traditional casting, by drawing lots"		"The same observer blinded to the method used to make the crown"		"The same observer blinded to the method used to make the crown"		"This program was calibrated before each measurement"	

frameworks were significantly smaller (1.2 ±2.2 to 48.8 ±13.5 μm).[30,46] For CoCr SC copings, 2 studies also showed conflicting findings; in the study of Park et al,[57] the CCT group displayed better marginal accuracy (58.3 ±31.3 μm) than the 3Shape group (88.9 ±39.4 μm). However, the opposite trend was presented in the study of Xu et al,[50] with MD values for the CCT group of 170.2 ±66.2 μm. For CoCr FDP frameworks, 2 available studies reported opposing outcomes.[53,61] According to Kim et al,[61] the CAD-CAM group (32 ±4.8 μm) displayed better marginal accuracy than the CCT group (64.1 ±14.2 μm). However, Örtorp et al[53] demonstrated that 3Shape milled FDP frameworks provided greater MD values (166 ±135 μm) than the CCT group (133 ±89 μm). Finally, both studies reported better marginal adaptation for the 3Shape DMLS process (47.3 ±8.6 to 84 ±60 μm) than CCT.[53,61] In the case of titanium SC copings, and on the basis of the findings of 2 studies, the MD values obtained by CAD-CAM systems were similar to those of the CCT groups (23.1 ±1.2 to 76.1 ±9.4 μm) irrespective of finish line type and manual refinement.[47,60] In the study of Shokry et al,[38] the marginal accuracy for titanium SC copings produced by the Everest system before (24.1 ±1.9 μm) and after (35.6 ±5.5 μm) porcelain firing was better than that of CCT. Finally, Torsello et al[59] reported smaller MD values (27 ±15 μm) in CAM StructSURE titanium IRFDP frameworks compared with the CCT group (78 ±48 μm)(Supplemental Table 1).

Overall, compared with the CM process, the majority of partial Y-TZP restorations or infrastructures produced by CAD-CAM milling technology exhibited better marginal adaptation.[26-29,31-33] In particular, 4 studies reported better marginal accuracy for Procera (86 ±64 μm), Cercon (49.5 ±24.5 to 84 μm), and Lava (24.6 ±14.0 μm) SC copings than for the CM (86.0 ±35.7 to 142 ±7 μm) groups.[27,29,31,48] For FDPs, 4 studies also demonstrated that the MD values for the Etkon (29.1 ±14.0 μm) and Cercon groups (71.4 ±8.4 to 85.7 ±38.8) were smaller than those obtained by the CM process (81.4 ±20.3 to 173.7 ±77.3 μm).[26,28,32,33]

When the DMLS manufacturing process was compared with CAD-CAM milling technology, CoCr infrastructures fabricated with CAD-CAM milling showed better marginal adaption,[57,58,61] except in the study of Örtorp et al.[53] For SCs, 2 studies reported greater MD values for the DMLS group (96.2 ±26.9 to 103.3 ±43.0 μm) compared with the CAD-CAM milling group (86.6 ±24.1 to 88.9 ±39.4 μm).[57,58] For FDPs, Kim et al[61] cited smaller MD values for Ceramill (32.6 ±4.8 μm) than for the DMLS group (47.3 ±8.6 μm). Compared with CCT, the majority of restorations or infrastructures produced by using the DMLS process exhibited better marginal accuracy.[34-37,50,53,61] Metal-ceramic SCs fabricated with the BEGO Medifacturing system exhibited smaller MD values (38 ±11.4 to 75.6 ±32.6 μm) than those of the CCT group (73 ±53.8 to 91.0 ±36.3 μm).[36,37] A similar pattern was also recorded for implant-retained SCs and IRFDPs irrespective of cement type and for 3Shape FDP frameworks.[34,35,53,61]

Compared with CEREC inLab technology, SCs fabricated with the SLC technique exhibited similar or better marginal accuracy[41,44,45] (Supplemental Table 1). In particular, In-Ceram zirconia SC copings produced with the SLC technique displayed similar (35.2 μm) or smaller MD values (25 ±18 μm) compared with the CEREC inLab groups.[44,45] According to Pelekanos et al,[41] for In-Ceram alumina SC copings, the SLC group elicited smaller MD values (60.1 ±39.5 μm) than those of the CEREC inLab group. However, with In-Ceram zirconia 3-unit FDPs, CEREC inLab MD values (53 ±17 μm) were smaller than those produced with the SLC technique, assuming that the marginal adaptation is affected by the type of dental restoration.[43]

With regard to lithium disilicate, the majority of SCs manufactured with the HP technique displayed equal or better marginal accuracy than did CAD-CAM technology[25,39,42,49,51](Supplemental Table 1). The study of Anadioti et al[39] reported that lithium disilicate SCs produced by using the conventional impression process and HP technique exhibited the best marginal accuracy (48 ±9 μm) compared with that of the E4D group (84 ±20 μm). These findings corroborate the results of 3 in vitro studies with MD values for HP groups ranging between 36 ±13.9 and 109.4 ±9 μm.[25,49,51] Also, the RCT of Akin et al[42] showed similar marginal adaptation for lithium disilicate SCs produced with the HP technique and CAD-CAM system. In contrast, 2 in vitro studies demonstrated smaller MD values for CAD-CAM lithium disilicate SCs (32.0 ±10.4 and 48 ±25 μm).[40,52] Finally, in interim restorations, poly(methylmethacrylate) FDPs fabricated directly showed similar MD values (81.2 ±35.6 μm) to those obtained from the CEREC system (87.9 ±15.3 μm).[54]

In answer to the second PICO question, the performance of a specific CAD-CAM system relative to marginal adaptation is influenced by the type of restorative material (Supplemental Table 2). According to Prasad and Al-Kheraif,[72] no significant differences in MD values were recorded in the KaVo Everest fully (67.7 ±5.4 μm) and partially sintered (58.6 ±4.4 μm) Y-TZP IRFDP superstructures or between partially sintered Y-TZP and leucite-reinforced glass ceramic groups (54.7 ±9.4 μm); however, the titanium group exhibited the lowest MD values (18.3 ±3.4 μm). The study of Romeo et al[73] also reported smaller MD values for DCS zirconia veneered with porcelain (47.2 ±17.8 μm) and titanium (50.8 ±12.4 μm) SCs than for the titanium veneered with composite resin (60.5 ±6.0 μm) and fiber-reinforced composite groups (75.3 ±11.5 μm). Additionally, in the study of Hamza et al,[68] the MD values for lithium disilicate SCs were significantly smaller (40.2 ±6.7 μm) than for zirconia SCs (86.1 ±28.8 μm). With respect to the performance of the Kavo Everest system, lithium disilicate SCs displayed approximately twice the MD values (28.1 ±7.9 μm) of zirconia SCs.[68]

In summary, 5 in vitro studies investigated the performance of a CAD-CAM system in restorations/infrastructures made of In-Ceram zirconia and presintered Y-TZP.[43,45,66,67,79] For SC copings, 2 studies showed smaller MD values for partially sintered Y-TZP copings (12.24 ±6.7 to 25.8 ±6.7 μm) than for In-Ceram zirconia.[45,79] In the case of 3-unit FDPs, Borba et al[67] concluded that CEREC inLab partially sintered Y-TZP frameworks displayed smaller MD values (75 ±39 μm) than those in the In-Ceram zirconia group (99 ±60 μm). In contrast, 2 studies demonstrated similar MD values for partially Y-TZP and In-Ceram zirconia 3-unit FDPs (53 ±9 to 66.8 ±33.2 μm).[43,66] Finally, equivalent MD values were recorded for CEREC InEos acrylate polymer and poly(methylmethacrylate) SCs (56.1 ±5.65 to 170 ±30 μm).[75,76]

Four comparative implant studies reported statistically smaller MD values for CAD-CAM CoCr (1.2 ±2.2 to 48.8 ±13.4 μm) and titanium (15.2 ±12.9 to 24.6 ±16.6 μm) IRFDP infrastructures compared with zirconia groups (5.9 ±3.6 to 103.8 ±43.1 μm).[25,46,67,70] Only Abduo et al[65] reported similar vertical fit values for titanium (3.6 ±0.9 μm) and zirconia (3.7 ±1.1 μm) Procera 3-unit IRFDP frameworks. Two studies also reported smaller MD values for 4-unit CoCr frameworks (32.0 ±34.9 to 56.9 ±27.4 μm) than for zirconia groups (62.8 ±41.6 to 127.2 ±66.9 μm).[71,74]

Multiple techniques were used to quantitatively assess the MD of the included comparative studies. Although the impression replica technique represents a noninvasive method, it is complicated and inaccurate; in the event of small discrepancies, the impression material may be distorted or damaged.[11,88] Scanning electron microscopy without sample sectioning can be performed in a limited crown area because the sections require a minimum thickness.[41] Computerized x-ray microtomography produces high-resolution images for both quantitative and qualitative analyses of the tooth, bone, and implants. Finally, no consensus has been reached on the appropriate number (20 or 50) of MD measurements for crowns and dies.[30,89,90]

In this systematic review, the variety of restorative materials and CAD and/or CAM systems, the use of multiple terms to define marginal adaptation, and the presence of different techniques for quantifying MD impeded direct comparisons. Additionally, most dental restorations were fabricated and examined under in vitro conditions, which increases efficiency and pairs the advantage of reproducibility with the potential for standardizing test parameters.[91] However, the outcomes of in vitro studies may deviate from those of clinical studies and should therefore be interpreted prudently. In particular, the included in vitro studies dictated that the measurements be performed before cementation or porcelain addition, which limits clinical relevance. Future in vivo studies addressing the research questions of this systematic review and investigating the effect of those critical factors on marginal adaptation should cover the whole spectrum of fixed dental restorations, including IRFDPs and multiunit FDP.

CONCLUSIONS

On the basis of the findings of the systematic review, the following conclusions were drawn:

1. Most of the comparative studies involved CAD-CAM dental restorations or infrastructures within the clinically acceptable MD range.

2. The performance of a CAD-CAM system relative to marginal adaptation is influenced by the restorative material.
3. Compared with CAD-CAM technology, SCs fabricated with the SLC technique exhibited similar or better marginal accuracy.
4. Most of the studies demonstrated that compared with CAD-CAM technology, HP lithium disilicate SCs displayed equal or better marginal accuracy. Compared with zirconia, cobalt-chromium, and titanium implant infrastructures produced using a specific CAD-CAM system, they also displayed smaller MD values.
5. Compared with CCT, most of the restorations or infrastructures produced by DMLS displayed better marginal accuracy.
6. Compared with CM, most of the zirconia restorations or infrastructures produced by using CAD-CAM milling exhibited smaller MD values.
7. No clear conclusions can be drawn relative to marginal adaptation about the superiority of CAD-CAM milling technology as opposed to the CCT and DMLS processes.

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