

COMPARATIVE EVALUATION OF THE MARGINAL FIT AND THICKNESS OF COBALT-CHROMIUM METAL COPINGS FABRICATED USING CAD/CAM AND DIRECT METAL LASER SINTERING – AN INVITRO STUDY

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Abstract

Aim: To evaluate and compare the marginal fit and thickness of cobalt-chromium (Co-Cr) metal copings fabricated using computer-aided design/computer-aided manufacturing (CAD/CAM) milling and direct metal laser sintering (DMLS) techniques.

Settings and Design: This study is an invitro analysis of the CAD/CAM and DMLS cobalt chromium metal copings.

Methods and Material: A standardized typodont molar tooth was prepared and scanned to obtain a digital model using CAD software. A total of thirty-two Co-Cr copings were fabricated for two groups: Group I (n = 16) – CAD/CAM-milled copings, and Group II (n = 16) – DMLS-fabricated copings. Marginal fit was evaluated under a stereomicroscope at four predetermined sites (mid-buccal, mid-palatal, mid-mesial, mid-distal). Thickness was measured using a thickness gauge at the same sites.

Statistical analysis used: Data were analysed using

independent t-tests with a significance level of $p < 0.05$.

Results: DMLS copings exhibited significantly superior marginal fit compared to CAD/CAM copings ($p < 0.05$). The mean marginal discrepancy for CAD/CAM ranged from 88.9 to 90.1 \pm 4.2 μ m, whereas for DMLS it ranged from 65.4 to 67.0 \pm 5.6 μ m. Thickness values showed greater uniformity in DMLS copings, with statistically significant differences between the two groups across all sites ($p < 0.0001$).

Conclusion: Within the limitations of this in vitro study, DMLS fabricated Co-Cr copings demonstrated better marginal adaptation and more consistent thickness compared to CAD/CAM-milled copings. These findings suggest that DMLS may provide enhanced marginal fit and thickness in prosthodontic restorations.

Keywords: direct metal laser sintering, CAD/CAM, cobalt-chromium copings, marginal fit, thickness.

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Introduction:

The accuracy of marginal fit and the uniformity of coping thickness are fundamental determinants of the long-term success of fixed dental prostheses. Inaccurate adaptation at the margins of restorations can lead to microleakage, plaque accumulation, secondary caries, and periodontal breakdown, thereby compromising clinical outcomes and patient satisfaction. Similarly, variations in coping thickness influence the strength of the restoration, aesthetic performance of veneering porcelain, and overall biomechanical stability.^{1,2}

Traditionally, the lost-wax casting technique was the mainstay for fabricating metal copings. Although widely used, this method is prone to inaccuracies due to multiple manual steps and technical sensitivity. With advancements in digital dentistry, such as subtractive manufacturing technique like CAD/CAM milling and additive manufacturing technique like DMLS, have emerged as alternatives that promise superior precision, reproducibility, and efficiency but the necessity to compare and analyse the best among these methods lead to this study.³⁻⁵

The CAD/CAM system fabricates copings by milling a pre-sintered or solid metal block based on digital designs generated through intraoral or laboratory scanners. This subtractive method ensures standardized production with reduced operator dependence. However, limitations such as tool wear, difficulty in replicating intricate geometries, and material wastage may affect marginal adaptation and uniformity of thickness.^{6,7}

DMLS, an additive manufacturing technique, builds copings layer by layer using a high-powered laser to sinter cobalt-chromium powder according to CAD designs. The layer-wise fabrication allows for accurate replication of complex anatomical features, minimal material

waste, and potentially enhanced marginal precision. Studies have demonstrated that additive techniques like DMLS can overcome the shortcomings of subtractive milling, providing restorations with improved fit and predictable thickness.⁸⁻¹⁰

Cobalt-chromium alloys continue to be the material of choice for metal copings in fixed prosthodontics owing to their excellent mechanical strength, corrosion resistance, and biocompatibility. The introduction of digital fabrication technologies has expanded the potential of these alloys by reducing errors and ensuring clinical acceptability of restorations.¹¹⁻¹⁴ Given the clinical relevance of marginal adaptation and coping thickness, it is imperative to compare the performance of different fabrication methods. Although multiple studies have evaluated CAD/CAM and DMLS techniques individually, comparative data regarding Co-Cr copings remain limited. This *in vitro* study was therefore designed to assess and compare the marginal fit and thickness of Co-Cr copings fabricated using CAD/CAM milling and DMLS, with the null hypothesis that there would be no significant difference between the two methods of fabrication.

Materials and Methods:

An experimental study was conducted to compare the marginal fit and thickness of cobalt-chromium (Co-Cr) copings fabricated by CAD/CAM milling and direct metal laser sintering (DMLS). This study was done in an *in vitro* setting over a period of six months from the procurement of materials, fabrication of the copings, statistical analyses and arriving at the final result. The ethical clearance for this study was obtained from the Institutional Ethical Committee (No:21/ETHICS/2023).

A standardized typodont molar tooth was

prepared with a chamfer finish line and a 6° taper according to accepted prosthodontic guidelines by Shillingburg. The tooth was scanned with a laboratory scanner (Trios Scanner, 3Shape, Denmark) to obtain a STL file. A coping was designed using CAD software (Exocad, 3Shape, Germany).¹⁵

The sample size was calculated by using OpenEpi software by which the mean and standard deviation for the sample size calculation were taken from the study done by Gunsoy S et al., the sample size of 16 per group was achieved.⁸

A total of 32 Co-Cr copings were fabricated and divided into two groups:

Group I (CAD/CAM): 16 copings milled from Co-

Cr alloy blocks (CORiTEC CoCr) using a 5-axis milling unit (CoriTec 350i, Imes-icore GmbH, Germany). [Figure 1]

Group II (DMLS): 16 copings fabricated layer by layer from Co-Cr metal powder (EOS CoCr) using a DMLS machine (EOS M100, EOS GmbH, Germany). [Figure 2]

Each coping was seated on the master die and evaluated under a stereomicroscope (Leica M205, Germany) at 30X magnification. Marginal gaps were measured at four predetermined sites—mid-buccal, mid-palatal, mid-mesial, and mid-distal. The mean value for each coping was calculated and expressed in micrometres (μm).³⁻⁶

Coping thickness was measured at the same four



Fig. 1: CAD CAM Cobalt Chromium Copings



Fig 2: DMLS Cobalt Chromium Copings

PROSTHETIC AND IMPLANT DENTISTRY

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sites using a digital thickness gauge (Kreoplin, Germany). Values were recorded in millimetre (mm), and mean thickness for each coping was calculated.⁸

Data were entered in Microsoft Excel and analysed using IBM SPSS (Version 25.0, IBM Corp., USA). Descriptive statistics (mean \pm SD) were calculated. Independent t-tests were used for intergroup comparisons, with a significance level set at $p < 0.05$.

Results:

A total of 32 Co-Cr copings were evaluated: 16 fabricated by CAD/CAM milling and 16 by DMLS.

The mean marginal gap values of CAD/CAM copings were significantly higher compared to DMLS copings at all four measurement sites ($p < 0.05$). The mean marginal discrepancy for CAD/CAM ranged from 88.9 to 90.1 \pm 4.2 μ m, whereas for DMLS it ranged from 65.4 to 67.0 \pm 5.6 μ m. All values fell within the clinically acceptable range ($< 120 \mu$ m). [Table 1] [Figure 3]

The mean thickness of DMLS copings was significantly lower and more uniform than that of CAD/CAM copings ($p < 0.0001$). CAD/CAM copings exhibited a mean thickness between 0.415–0.425 mm, while DMLS copings showed more consistent values of 0.351–0.362 mm across all sites. [Table 2] [Figure 4]

Table 1- Intergroup Comparison of Marginal Fit (μ m)

Site	CAD/CAM (Mean \pm SD)	DMLS (Mean \pm SD)	p-value
Mid-buccal	89.6 \pm 8.7	65.4 \pm 7.8	0.0001*
Mid-palatal	89.7 \pm 8.2	66.3 \pm 8.0	0.0001*
Mid-distal	89.0 \pm 8.1	67.1 \pm 8.7	0.0001*
Mid-mesial	90.2 \pm 8.2	66.7 \pm 8.3	0.0001*

*Statistically significant at $p < 0.05$

Table 2- Intergroup Comparison of Coping Thickness (mm)

Site	CAD/CAM (Mean \pm SD)	DMLS (Mean \pm SD)	p-value
Mid-buccal	0.415 \pm 0.037	0.352 \pm 0.029	0.0001*
Mid-palatal	0.419 \pm 0.039	0.351 \pm 0.033	0.0001*
Mid-distal	0.425 \pm 0.035	0.352 \pm 0.030	0.0001*
Mid-mesial	0.423 \pm 0.048	0.362 \pm 0.030	0.0001*

*Statistically significant at $p < 0.05$

Marginal fit: DMLS copings had significantly better adaptation than CAD/CAM.

Thickness: DMLS copings demonstrated more uniform and consistent coping thickness.

Discussion

The present study evaluated and compared the marginal fit and thickness of cobalt-chromium metal copings fabricated by CAD/CAM milling and DMLS methods. Within the limitations of this in vitro design, the results showed that DMLS copings exhibited significantly superior marginal fit and more uniform thickness compared to CAD/CAM copings.¹⁶⁻²⁰

Marginal adaptation is a key determinant of the longevity of fixed prostheses. Poor marginal fit predisposes to microleakage, secondary caries, and periodontal disease. The results of this study demonstrated mean marginal gaps of 65–67 μm for DMLS and 88–90 μm for CAD/CAM copings, both within the clinically acceptable range of $\leq 120 \mu\text{m}$.

These findings are consistent with previous studies. Vojdani et al. and Lövgren et al. reported that laser-sintered copings showed smaller marginal discrepancies compared to milled or conventionally cast copings. Similarly, Park et al. and Gautam et al. observed that DMLS provided improved marginal adaptation compared to casting techniques. In contrast, Doddy et al. reported superior accuracy for CAD/CAM zirconia copings compared to DMLS Co-Cr copings, highlighting that material type and processing parameters may influence outcomes.¹⁻⁵

The improved adaptation of DMLS in the present study can be attributed to its additive manufacturing process, where copings are built layer by layer, minimizing distortions associated with milling burs or casting shrinkage.

Uniform coping thickness is critical for ensuring adequate strength and providing sufficient space for veneering porcelain. In this study, DMLS copings demonstrated consistent thickness

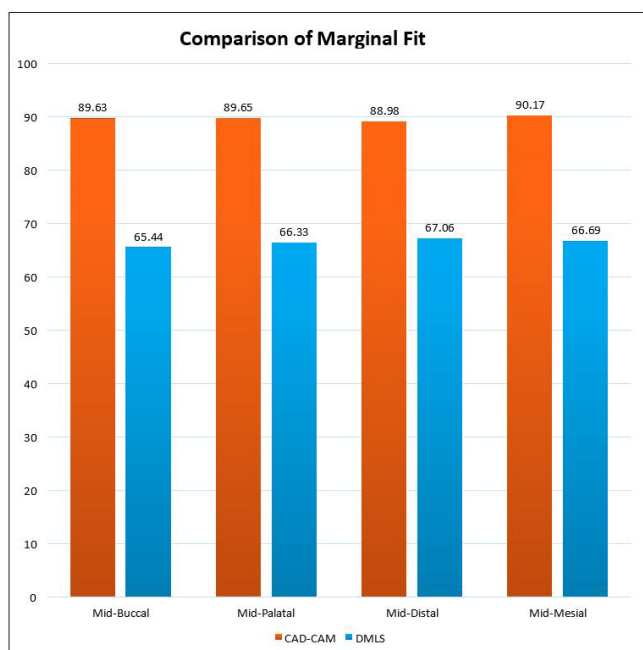


Fig. 3: Intergroup Comparison of Marginal Fit

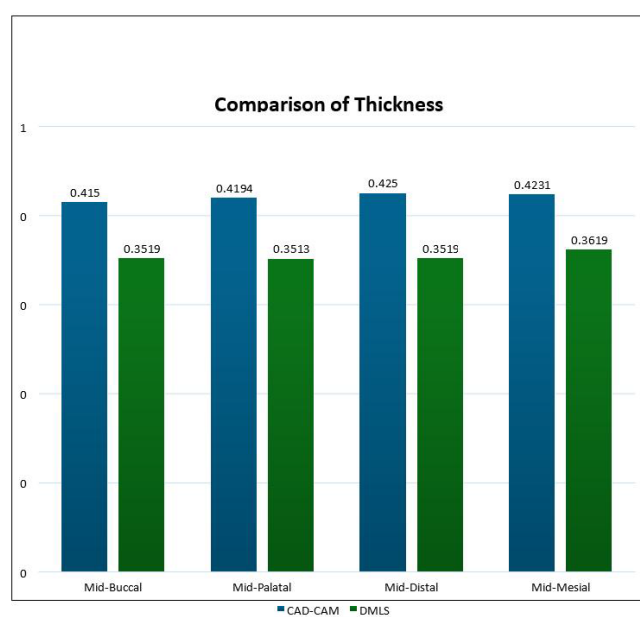


Fig. 4: Intergroup Comparison of Thickness

PROSTHETIC AND IMPLANT DENTISTRY

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(0.35–0.36 mm), whereas CAD/CAM copings showed slightly higher and more variable values (0.41–0.42 mm).

Shah et al. highlighted that coping thickness directly influences marginal adaptation, especially after porcelain firing cycles. Our findings support this by demonstrating that the precision of layer-by-layer fabrication in DMLS ensures dimensional stability and reproducibility. Kim et al. and Zeng et al. similarly reported that selective laser sintering and melting techniques produce copings with uniform thickness and acceptable marginal accuracy.⁶⁻⁸

The superior performance of DMLS copings in both fit and thickness has practical significance:

Better marginal adaptation reduces microleakage and risk of secondary caries.

Uniform thickness ensures structural durability and optimal esthetic veneering space.

Additive manufacturing enables fabrication of complex geometries, offering customized restorations.

Thus, DMLS may be a preferred option for posterior crowns and multi-unit fixed prostheses where precision and durability are paramount.

The strengths of this study are the use of standardized preparation, fabrication, and evaluation methods, which minimized variability. Both stereomicroscope and thickness gauge measurements allowed objective evaluation.

Limitations include the in vitro design, which does not replicate intraoral factors such as saliva, occlusal loading, and thermal cycling. Additionally, only a single alloy (Co-Cr) and coping design were evaluated. Future research should incorporate ceramic veneering, long-term mechanical testing, and clinical follow-up to validate these findings.

Overall, the findings of this study align with the majority of published literature indicating that DMLS provides enhanced marginal adaptation compared to subtractive and conventional techniques. However, the clinical acceptability of CAD/CAM copings remains high, and the choice of technique may depend on laboratory infrastructure, cost, and case-specific requirements.²¹⁻³⁰

Conclusion

Within the limitations of this in vitro study, cobalt-chromium copings fabricated using direct metal laser sintering (DMLS) demonstrated superior marginal adaptation and more uniform coping thickness compared to those fabricated using CAD/CAM milling. Both techniques produced values within clinically acceptable ranges; however, the enhanced precision and consistency of DMLS suggest it may offer better clinical outcomes for fixed prosthodontic restorations.

References

1. Vojdani M, Torabi K, Farjood E, Khaledi AAR. Comparison of marginal and internal fit of metal copings fabricated by using additive, subtractive, and conventional methods. *J Prosthet Dent.* 2013;109(3):121–125.
2. Lövgren N, Roxner R, Klemenz S, Larsson C. Effect of production method on surface roughness, marginal and internal fit, and retention of cobalt-chromium single crowns. *J Prosthet Dent.* 2017;118(1):95–101.
3. Park JK, Lee WS, Kim HY, Kim WC. Accuracy of metal copings fabricated by casting, CAD/CAM milling, and direct metal laser sintering systems. *J Prosthet Dent.* 2015;113(4):302–309.
4. Gautam N, Singh V, Singh RD. Comparative evaluation of marginal accuracy of Co-Cr copings fabricated using conventional and DMLS techniques: An in vitro study. *J Indian Prosthodont Soc.* 2021;21(2):127–133.
5. Doddy J, Kiran R, Shetty A. Comparative evaluation of marginal adaptation of cast Ni-Cr, DMLS Co-Cr, and CAD/CAM zirconia copings: An in vitro study. *J Prosthet Dent.* 2019;122(2):146–152.
6. Shah S, Jain V, Doshi P. Effect of coping thickness on marginal fit of metal-ceramic restorations fabricated by DMLS after multiple firings. *J Prosthet Dent.* 2022;128(3):279–286.
7. Kim KB, Kim JH, Kim WC, Kim HY. Evaluation of marginal and internal gaps of metal-ceramic crowns fabricated by selective laser sintering technology. *J Prosthet Dent.* 2013;110(6):537–543.
8. Gunsoy S, Ulusoy M. Evaluation of marginal/ internal fit of chrome-cobalt crowns: Direct laser metal sintering versus

PROSTHETIC AND IMPLANT DENTISTRY

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- computer-aided design and computer-aided manufacturing. *Niger J Clin Pract* 2016;19:636-44.
9. Arora A, Bhola R, Srivastava A. Comparative evaluation of marginal fit of copings fabricated by casting, CAD/CAM, and DMLS. *Indian J Dent Res*. 2018;29(2):131–135.
 10. Chekkarraj S, et al. Comparison of marginal fit of CAD/CAM and DMLS copings with different finish lines: An in vitro study. *J Prosthet Dent*. 2020;124(5):588–594.
 11. Koutsoukis T, Zinelis S, Eliades G. Selective laser melting technique of Co-Cr dental alloys: A review of structure and properties. *J Prosthodont Res*. 2015;59(3):197–202.
 12. Huang Z, Zhang L, Zhu J. Marginal and internal fit of metal-ceramic crowns fabricated by selective laser melting vs casting. *J Prosthet Dent*. 2019;122(3):362–367.
 13. Tomar BS, et al. Evaluation of marginal accuracy of DMLS and lost wax Co-Cr copings: An in vitro study. *J Indian Prosthodont Soc*. 2023;23(1):34–40.
 14. Alex D, et al. Marginal accuracy of Ni-Cr copings fabricated using conventional and accelerated casting techniques. *J Indian Prosthodont Soc*. 2015;15(1):25–30.
 15. Bhaskaran E, et al. Comparative evaluation of marginal and internal fit of Co-Cr copings fabricated by conventional, resin-printed, and DMLS techniques. *J Indian Prosthodont Soc*. 2013;13(3):189–195.
 16. Riccitiello F, et al. Evaluation of marginal and internal fit of CAD/CAM zirconia and lithium disilicate crowns. *Clin Oral Investig*. 2018;22(3):1303–1312.
 17. Dixit SY, et al. Evaluation of marginal fit of CAD-CAM zirconia, SMLS Co-Cr, pressable lithium disilicate, and cast Ni-Cr copings: An in vitro study. *J Prosthet Dent*. 2016;116(1):80–85.
 18. Bae S, et al. Accuracy and precision of 3D-printed fixed dental prostheses: A systematic review and meta-analysis. *J Prosthet Dent*. 2020;123(6):803–810.
 19. Prabhu R, et al. Five-year clinical performance of DMLS-fabricated metal-ceramic fixed partial prostheses. *J Indian Prosthodont Soc*. 2016;16(2):135–141.
 20. Moraru L, et al. Mechanical and surface properties of SLM-manufactured dental prostheses: A review. *J Prosthet Dent*. 2023;130(1):1–10.
 21. Özal Ç, Ulusoy M. Evaluation of marginal and internal fit of monolithic zirconia restorations fabricated with different scanning technologies. *Int J Prosthodont*. 2021;34(2):152–160.
 22. Majeed ZA, et al. Accuracy of Co-Cr copings fabricated by casting, CAD/CAM, and additive manufacturing: A comparative study. *J Prosthet Dent*. 2023;130(5):643–650.
 23. Di Fiore A, et al. Methods for evaluating marginal and internal fit of partial crowns: A systematic review. *J Prosthet Dent*. 2023;129(6):753–761.
 24. Gholamrezaei M, et al. Comparison of fit of Co-Cr copings fabricated by SLM and casting. *J Prosthet Dent*. 2020;123(3):441–447.
 25. Chandrashekar S, et al. Marginal adaptation of zirconia and Ni-Cr copings with shoulder finish lines: An in vitro study. *J Indian Prosthodont Soc*. 2012;12(4):219–224.
 26. Harish V, et al. Evaluation of marginal and internal fit of two different metal-ceramic systems. *J Indian Prosthodont Soc*. 2014;14(3):228–234.
 27. Karataşlı O, et al. Marginal fit of copings fabricated using different CAM systems. *J Prosthet Dent*. 2011;106(4):249–255.
 28. Dave R, et al. Influence of die spacer design on marginal fit and retention of copings. *J Prosthodont*. 2020;29(3):215–221.
 29. Sankari S, et al. Marginal and internal fit of copings fabricated by conventional, resin printing, and CAD/CAM techniques. *J Prosthet Dent*. 2022;127(5):603–609.
 30. Gaikwad A, et al. Comparative evaluation of marginal fit and axial adaptability of copings fabricated by MLS and LWT. *J Prosthet Dent*. 2018;119(3):398–403.

List of Abbreviations

Abbreviation	Definition
CAD/CAM	Computer-Aided Design/Computer-Aided Manufacturing
STL	Standard Tessellation language
DMLS	Direct Metal Laser Sintering
Co-Cr	Cobalt Chromium