Review Article

Techniques for Evaluation of Marginal and Internal Fit of Implant-Supported Crowns: A Comprehensive Review of Contemporary Methods

Ruhani Daultani[1], Kirti Jajoo Shrivastava[2], Nivedita Singh[3], Ankit Yadav[4], Gokul Chhabra[5] Shivani Mahajan[6]

[1]Postgraduate student, Department of Prosthodontics, Crown and Bridge, People's College of Dental Sciences and Research Centre, People's University, Bhopal, drruhaniprostho@gmail.com
[2]Professor, Department of Prosthodontics, Crown and Bridge, People's College of Dental Sciences and Research Centre, People's University, Bhopal, kirti.jajoo@gmail.com
[3]Postgraduate student, Department of Prosthodontics, Crown and Bridge, People's College of Dental Sciences and Research Centre, People's University, Bhopal, nvdt.singh21@gmail.com
[4]Postgraduate student, Department of Prosthodontics, Crown and Bridge, Bhabha College of Dental Sciences, Bhopal, ashuy030@gmail.com
[5]Postgraduate student, Department of Prosthodontics, Crown and Bridge, People's Dental Academy, People's University, Bhopal, gokulchhabra2@gmail.com
[6]Postgraduate student, Department of Prosthodontics, Crown and Bridge, People's College of Dental Sciences and Research Centre, People's University, Bhopal, shivani.mahajan1997@gmail.com

Abstract

Marginal and internal fit are important determinants of the biological and mechanical success of implant-supported crowns. Inaccurate fit may contribute to plaque retention, microleakage, cement dissolution, peri-implant tissue irritation, screw-related complications, loss of retention, and long-term prosthetic failure. Because of this, evaluation of fit has become a major topic in prosthodontic research and in contemporary digital restorative workflows. Over the years, methods of fit assessment have evolved from simple visual and sectional procedures to advanced non-destructive three-dimensional digital techniques. Broadly, available methods can be classified as destructive or non-destructive, and as two-dimensional or three-dimensional approaches. Conventional techniques such as direct microscopy, clinical probing, radiographic assessment, and sectioning remain widely described, but each has important limitations, particularly when complete internal adaptation or whole-surface analysis is required. Replica-based techniques, especially the silicone replica method, continue to be widely used because they are practical, economical, and non-destructive. More recently, triple-scan workflows, CAD-based superimposition, and micro-computed tomography have expanded the ability to evaluate fit in three dimensions with improved precision and reproducibility. For implant-supported crowns, where the crown-abutment interface is clinically critical, digital and non-destructive methods are increasingly preferred. However, no single method is ideal in every setting. This review summarizes the principles, indications, strengths, limitations, and clinical relevance of the main contemporary methods used to evaluate the marginal and internal fit of implant-supported crowns and highlights the current shift toward digital, three-dimensional, and non-destructive analysis.

Received date: 2/1/2026
Accepted date: 10/2/2026
Published date: 09/4/2026

Keywords: Marginal fit, micro-computed tomography, implant supported crowns

INTRODUCTION:

Marginal and internal adaptation are fundamental quality requirements for indirect restorations, including implant-supported crowns. A restoration with poor fit may not seat completely, may produce an uneven cement space, and may create areas that favor bacterial accumulation or mechanical stress concentration. In implant prosthodontics, these concerns are especially important because implants lack the shock-absorbing capacity of the periodontal ligament and depend on precise component adaptation for long-term mechanical stability and peri-implant health [1,2].

The importance of fit has been recognized for decades. McLean and von Fraunhofer are frequently cited for the classical clinical discussion of cement film thickness and for the often-quoted threshold of approximately 120 µm as a clinically acceptable marginal discrepancy, although this value should not be applied rigidly to every clinical situation [1]. Holmes and co-workers later clarified that terms such as marginal gap, internal gap, vertical discrepancy, horizontal discrepancy, absolute marginal discrepancy, and seating discrepancy are not interchangeable. Their work remains important because many studies still use different terminology for related but distinct geometric relationships [2].

Another major issue in the literature is methodological variability. Some studies assess only external margins, whereas others examine internal adaptation as well. Some report a few selected points, whereas others analyze many sites or even whole surfaces. Groten et al. showed that the number of measurement points matters greatly and that a very small number of readings may not be sufficient to represent the true marginal condition of a restoration [3]. This observation remains relevant, especially in implant prosthodontics, where local discrepancies at the crown-abutment interface may have biological and mechanical consequences.

The fit of implant-supported prostheses has therefore attracted growing attention. A critical review by Abduo et al. emphasized that accurate fit is essential, but also highlighted that the available methods differ widely in principle, precision, and clinical applicability [4]. Since then, more recent comparative and review papers have shown that fit assessment is moving away from purely local two-dimensional measurements toward software-assisted, non-destructive, three-dimensional evaluation [5-7]. At the same time, traditional methods such as the silicone replica technique still remain widely used because they are practical and economical [8]. This review discusses the major methods used to evaluate the marginal and internal fit of implant-supported crowns.

Importance of Marginal and Internal Fit in Implant-Supported Crowns

Marginal fit refers to the adaptation at the edge of the restoration, while internal fit refers to the space between the intaglio surface of the crown and the abutment. In implant-supported crowns, both are important. A marginal discrepancy may expose luting cement, promote plaque accumulation, and increase the risk of peri-implant inflammation. An internal discrepancy may alter seating, create an uneven cement layer, and influence how forces are transmitted to the abutment, screw, and implant components [2,4].

Biological and technical complications are often interrelated. Excess cement associated with poor marginal adaptation has been implicated in peri-implant soft tissue problems, whereas inaccurate internal fit may contribute to incomplete seating and eventual mechanical issues. For this reason, fit is not merely a laboratory parameter; it has direct clinical consequences. Abduo's review on implant frameworks also emphasized that better fit is desirable not only for biological reasons, but also for reducing stress and improving prosthetic longevity [9].

Fit has become even more relevant as restorative workflows have changed. Implant-supported crowns are now fabricated through conventional casting, subtractive CAD/CAM milling, additive manufacturing, and hybrid digital workflows. These fabrication differences can influence both marginal and internal adaptation. A recent systematic review and meta-analysis comparing digital and conventional impressions for full-coverage restorations found that digital workflows have become highly relevant to fit studies, particularly because they offer new possibilities for measurement and comparison [10]. Similarly, a meta-analysis by Mai et al. highlighted the increasing use of digital methods for fit evaluation and the need to understand their accuracy and limitations [11].

Classification Overview of Fit Evaluation Methods

Fit evaluation methods can first be classified according to their nature as destructive or non-destructive. Destructive methods require the specimen to be cut or otherwise permanently altered to expose the interface for measurement. Their main advantage is direct access to the gap, but the major disadvantage is that the specimen cannot be reused. Non-destructive methods preserve the restoration and allow repeated measurements, which is especially useful in experimental studies comparing different stages of fabrication or cementation [4-7].

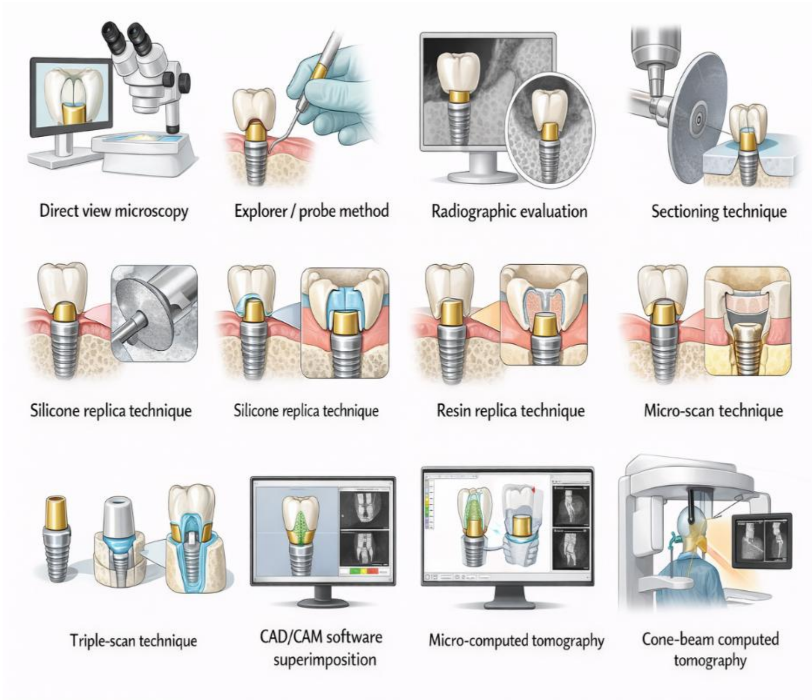
A second major classification is based on dimensional analysis, dividing methods into two-dimensional and three-dimensional approaches. Two-dimensional methods provide linear data at selected points or along selected sections. They are often simpler and less expensive, but they offer only partial information. Three-dimensional methods analyze a greater portion of the interface, sometimes the whole surface, and therefore provide a more comprehensive understanding of adaptation. Recent comparison studies and systematic reviews increasingly favor three-dimensional methods, especially when the objective is to assess internal adaptation or complex implant-supported restorations [5-7,11].

A third practical classification is according to setting. Some methods are mainly clinical, such as tactile probing and radiographic examination. Others are mainly laboratory-based, such as direct microscopic viewing and sectioning. Digital methods may bridge both settings, because scans can be obtained in the clinic or laboratory and then analyzed virtually. This classification is important because the most suitable method depends not only on theoretical accuracy, but also on whether the aim is chairside assessment, laboratory comparison, or high-level prosthodontic research [4,7].

Overall, recent reviews show a clear trend toward non-destructive and three-dimensional analysis. This does not mean that older methods are obsolete, but it does mean that their limitations must be recognized more clearly than in the past. Modern prosthodontic research increasingly values methods that are repeatable, less operator-dependent, and capable of whole-surface assessment [5-7].

Table 1. Classification of methods used for evaluation of marginal and internal fit of implant-supported crowns

Method	Category by nature	Dimensional analysis	Destructive / Non-destructive	Main area assessed
Direct view microscopy	Conventional	2D	Non-destructive	External marginal fit
Explorer / probe method	Clinical	Qualitative	Non-destructive	Marginal discrepancy
Radiographic evaluation	Clinical	2D	Non-destructive	Mainly proximal marginal fit
Sectioning technique	Conventional	2D	Destructive	Marginal and internal fit
Silicone replica technique	Replica-based	2D	Non-destructive	Marginal and internal fit
Resin replica technique	Replica-based	2D	Non-destructive	Marginal and internal fit
Triple-scan technique	Digital	3D	Non-destructive	Marginal and internal fit
CAD/CAM software superimposition	Digital	3D	Non-destructive	Whole-surface fit analysis
Micro-computed tomography	Advanced imaging	3D	Non-destructive	Marginal and internal fit
Cone-beam computed tomography	Advanced imaging	3D	Non-destructive	Limited use for fit evaluation



Conventional Methods

Direct View Technique

The direct view technique is one of the oldest and most commonly used methods for marginal fit assessment. In this method, the crown is seated on the abutment or die and the marginal discrepancy is measured directly under magnification, usually with a stereomicroscope or optical microscope. The method is straightforward and has been widely used because it allows direct visualization of the external margin [5]. Its main strength is simplicity. It is relatively easy to perform in vitro, does not require expensive digital infrastructure, and permits direct measurement of vertical marginal discrepancy at selected sites. For this reason, direct microscopy remains common in studies comparing restorative materials, manufacturing techniques, and impression workflows [5,7].

However, the method has clear limitations. It is essentially a two-dimensional technique and is restricted largely to external marginal assessment. It provides little or no information about the internal adaptation of the crown. Results also depend heavily on the number and location of measurement points. As Groten et al. pointed out, using too few points can produce an incomplete and potentially misleading picture of fit [3]. Therefore, although direct microscopy remains useful, it should be understood as a localized rather than comprehensive method.

Explorer or Probe Method

The explorer method is a simple chairside technique in which a sharp explorer is moved across the restoration margin to identify open margins, overhangs, or steps. It is fast, inexpensive, and part of routine clinical practice. In implant dentistry, the method is often used at the time of prosthesis delivery as a quick screening tool [4]. Its main limitation is that it is subjective. The result depends on operator experience, tactile sensitivity, access to the margin, and lighting conditions. It does not provide quantitative data and cannot be used reliably for research-level comparison. Around implant-supported crowns, where margins may be subgingival or difficult to access, the method becomes even less dependable as a standalone approach [4]. For this reason, the explorer method is best considered an adjunctive clinical tool rather than a formal measurement technique.

Radiographic Evaluation

Radiographic assessment, usually with periapical or bitewing radiographs, is another commonly used clinical method. It is especially useful for evaluating interproximal seating and marginal adaptation in areas where direct visualization is limited. In implant-supported crowns, radiographs are often used to verify complete seating and to look for excess cement [4]. Despite its clinical usefulness, radiography is limited by its two-dimensional nature. Buccal and lingual discrepancies cannot be evaluated accurately, and minor gaps may be obscured by angulation errors or material radiopacity. It is therefore useful as a screening or adjunctive method but not as a comprehensive technique for research on marginal and internal fit [4,7].

Sectioning Technique

The sectioning technique is a classic destructive method. The crown is seated or cemented, the specimen is sectioned through one or more planes, and the exposed internal and marginal interfaces are measured under magnification. Historically, sectioning has been regarded as a highly accurate method because it allows direct observation of the internal space [5,7]. The main problem is that the specimen is destroyed. This prevents repeated measurements and limits the analysis to the selected cut planes. It also raises the possibility of sectioning artifacts. Nevertheless, sectioning has long been used as a reference method in prosthodontic studies because of its directness. Even now, it remains valuable when a high-detail sectional evaluation is needed and specimen destruction is acceptable [5,7].

Table 2. Comparison of conventional and replica-based methods for fit evaluation

Method	Principle	Advantages	Limitations	Common use
Direct microscopy	Crown seated and margin directly viewed under microscope	Simple, direct visualization, widely used	Only 2D, limited to external margins	In vitro marginal gap studies
Explorer / probe	Tactile evaluation of crown margin	Quick, chairside, inexpensive	Subjective, non-quantitative	Clinical screening
Radiographic evaluation	Periapical or bitewing image used to assess seating and margin	Useful for proximal surfaces, routine clinical use	Image distortion, no buccolingual assessment	Clinical adjunct
Sectioning technique	Crown is sectioned and internal	High accuracy, direct internal	Destructive, limited section	Laboratory research

	gap is measured	visualization	planes	
Silicone replica technique	Silicone layer represents internal space and is sectioned for measurement	Non-destructive, economical, widely validated	Technique-sensitive, only 2D sections	Research and comparative studies
Resin replica technique	Resin film used instead of silicone	Good stability	More complex, less commonly used	Specialized laboratory studies

Replica-Based Methods

Silicone Replica Technique

Among non-destructive methods, the silicone replica technique is one of the most widely used. Light-body silicone is placed inside the crown, the crown is seated under controlled force, and the resulting thin silicone layer represents the space between the crown and abutment. This layer is then stabilized with a heavier silicone material, sectioned, and measured under a microscope. Laurent et al. validated the silicone replica method for clinical evaluation of crown fit, and since then it has become a standard approach in prosthodontic research [8]. The method is popular for good reasons. It is non-destructive, relatively inexpensive, and versatile. It can be used in vitro and, in some situations, in vivo. It is also applicable to both tooth-supported and implant-supported restorations. Because of these advantages, it has been widely used in studies comparing conventional and digital workflows, materials, and manufacturing methods [5-7,10].

However, the silicone replica technique is still basically a two-dimensional method because the replica is measured after sectioning. It is also technique-sensitive. Seating pressure, silicone viscosity, stabilization, sectioning direction, and the exact points chosen for measurement can all affect the result. This means that, while the method is highly practical, it requires careful standardization. More recent work comparing digital and replica methods suggests that the silicone replica technique remains useful, but may differ from three-dimensional digital methods in some regions of the restoration [15].

Resin Replica Technique

The resin replica technique follows a similar principle but uses resin material instead of silicone. It has the theoretical advantage of better dimensional stability in some situations, but it is more technique-sensitive and less commonly used than the silicone replica method. In current prosthodontic literature, resin replicas are mentioned less often, and silicone remains the preferred replica material because it is easier to manipulate and has been better validated [6,7].In implant-supported crown studies, the resin replica technique has only a limited role today. Most investigators who want a practical, non-destructive conventional method choose silicone rather than resin. Therefore, although the resin replica method deserves mention in classification systems, it is not a dominant contemporary technique.

Digital and Advanced Methods

Triple-Scan Technique

The triple-scan technique represents an important step in the transition from two-dimensional to three-dimensional fit analysis. In its classic form, three scans are made: the restoration alone, the abutment or die alone, and the restoration seated on the abutment. These digital datasets are then superimposed using software, allowing the internal and marginal fit to be assessed in three dimensions. Holst et al. introduced this protocol to overcome the loss of information associated with traditional two-dimensional methods [12].

The triple-scan method has several major advantages. It is non-destructive, provides three-dimensional information, allows repeated measurements, and fits naturally into digital workflows. Holst and co-workers later extended this concept to multi-unit screw-retained implant restorations, demonstrating its usefulness in implant prosthodontics as well [13]. For implant-supported crowns, this is highly relevant because the prosthetic interface is spatially complex and may not be adequately represented by a few sectional measurements. The limitations of the triple-scan method are mostly technical. Accurate scanning, reliable superimposition, and appropriate software handling are essential. Surface reflectivity, scan noise, and registration errors can influence the results. Even so, this method is now considered one of the most informative non-destructive approaches for research involving digital restorations and implant-supported prostheses [11-13].

CAD/CAM Superimposition and Software-Based Analysis

A closely related category includes CAD/CAM-based digital analysis in which STL files or other digital datasets are compared in software. This approach may or may not formally follow a triple-scan protocol, but the principle is similar: digital surfaces are superimposed and the gap is assessed computationally. Such methods have become very important in studies comparing conventional impressions, digital impressions, milled restorations, and additively manufactured restorations [9-11]. One of the major strengths of digital superimposition is that it allows detailed regional or whole-surface mapping. Results can be displayed numerically or as color maps, which makes interpretation easier and often more informative than single-point values. Park et al. described a fully digital technique for in vivo assessment of internal and marginal fit, showing that digital analysis is no longer confined to laboratory settings [14]. This is particularly important in modern prosthodontics, where clinical and laboratory workflows are becoming increasingly integrated.

At the same time, digital methods are not automatically free from error. Mai et al. emphasized that scanner resolution, alignment algorithms, and methodological standardization strongly influence the reliability of digital measurement methods [11]. Hasanzade et al. directly compared a three-dimensional digital technique with the two-dimensional replica method and found that the two approaches can produce different results depending on the region measured [15]. This means digital methods are powerful, but they still require careful calibration and interpretation.

High-Precision Three-Dimensional Imaging

Micro-Computed Tomography

Micro-computed tomography, or micro-CT, is widely regarded as one of the most precise non-destructive methods for fit evaluation. It allows the internal and external interfaces of a restoration to be visualized without sectioning, and measurements can be made in multiple planes or over reconstructed three-dimensional volumes. For implant-supported crowns, micro-CT is particularly attractive because it can evaluate both marginal and internal adaptation in a detailed and reproducible manner [5,7]. Moris et al. used micro-CT to analyze implant-supported crowns fabricated by different manufacturing methods and demonstrated its value for evaluating both internal and external marginal fit [16]. This work is especially relevant because it concerns the exact kind of restorations considered in this review. The method can reveal discrepancies that may not be visible with simpler two-dimensional techniques.

Micro-CT has also been used in studies comparing different fabrication routes for implant-supported metal copings and multi-unit substructures. Yildirim and Paken evaluated implant-supported metal copings made with three different techniques, while Kayikci and Ates assessed three-unit implant-supported prosthetic substructures fabricated by CAD/CAM systems [17,18]. These studies show that micro-CT and related advanced assessment methods are highly useful in implant prosthodontics when the goal is to compare manufacturing precision. The main disadvantages of micro-CT are cost, limited availability, and the need for specialized software and expertise. In addition, the final numerical results can be influenced by voxel size, thresholding, and segmentation strategy. Therefore, micro-CT is best regarded as a high-level research method rather than a routine clinical tool [5-7].

CBCT

Cone-beam computed tomography has occasionally been proposed as a three-dimensional alternative because it is more widely available in dentistry than micro-CT. However, its application to precise fit measurement is limited. Doriguêtto et al. found that CBCT overestimated marginal mismatch and showed low diagnostic accuracy for gap detection when compared with micro-CT [19]. The lower spatial resolution of CBCT and the presence of artifacts, especially around dense restorative materials, limit its value for fine marginal and internal gap analysis. Thus, although CBCT is very useful for many diagnostic tasks in dentistry, it is not considered a dependable choice for detailed fit evaluation of implant-supported crowns [19].

Table 3. Comparison of digital and advanced methods for fit evaluation

Method	Principle	Advantages	Limitations	Accuracy / relevance
Triple-scan technique	Three scans are superimposed digitally for gap analysis	Non-destructive, 3D, reproducible	Requires scanner accuracy and software skill	High
CAD/CAM digital superimposition	STL files or digital surfaces are overlapped and analyzed	Whole-surface mapping, color-coded analysis, repeatable	Depends on alignment quality and software	High
Micro-CT	Internal and marginal gaps assessed from high-resolution tomographic images	Very high accuracy, 3D, no sectioning	Expensive, limited availability, research-oriented	Very high / gold standard
CBCT	3D imaging using cone-beam	More accessible than micro-	Lower resolution, artifact-	Low to moderate for this

	tomography	CT	prone, limited reliability	purpose

Comparison of Methods and Clinical Relevance

No single method is ideal in every situation. The choice depends on whether the aim is quick clinical screening, routine laboratory evaluation, or high-precision research. In clinical practice, direct visual inspection, probing, and radiographs remain practical because they are quick and easily available. However, they are limited and should not be mistaken for comprehensive methods [4]. For conventional laboratory research, direct microscopy and the silicone replica technique remain useful because they are accessible and comparatively simple. Among these, the silicone replica technique still offers one of the best balances between practicality and non-destructive assessment [8]. Its continued popularity in prosthodontic studies reflects this balance.

When the aim is a more complete evaluation, especially for implant-supported crowns and digital workflows, three-dimensional digital methods are more informative. Triple-scan protocols, CAD superimposition, and micro-CT provide broader surface analysis, can often be repeated, and align better with modern CAD/CAM prosthodontics [11-16]. These techniques are increasingly favored in contemporary literature for precisely these reasons [5-7]. This shift is also visible in implant-specific studies. Abduo's review of CAD/CAM implant frameworks highlighted the growing role of digitally fabricated prostheses and the need for accurate methods to assess their fit [9]. More recent implant studies have continued this direction. Yildirim and Paken showed that the fabrication route affects marginal and internal adaptation in implant-supported metal copings [17]. Kayikci and Ates reported comparable concerns for three-unit implant-supported substructures fabricated by CAD/CAM systems [18]. Giti and Farrahi, in a recent study on 3-unit implant-supported fixed partial dentures, further demonstrated that fabrication method can influence marginal adaptation [20]. Together, these reports confirm that method selection is not merely a technical issue; it influences how modern implant prosthodontic research interprets restorative accuracy.

Future Directions

The future of fit evaluation is clearly moving toward digital, non-destructive, and three-dimensional approaches. Recent reviews emphasize not only the advantages of these methods, but also the need for better standardization in scanning, superimposition, measurement regions, and data reporting [6,7,11]. Without such standardization, even advanced digital methods may produce results that are difficult to compare across studies. Another major future direction is the closer integration of measurement methods with clinical workflows. As intraoral scanning and digital prosthesis design become more common, methods like triple-scan analysis and in vivo digital superimposition may become increasingly practical for postgraduate clinics and advanced prosthodontic centers [12-15]. This would allow fit evaluation to move from being purely a research activity to becoming a more clinically relevant part of quality control.

At the same time, future work should not focus only on measurement accuracy. It should also examine how measured discrepancies relate to real biological and mechanical outcomes in implant-supported crowns. A method may be extremely precise, but its clinical value will be greatest when its findings can be linked clearly to peri-implant tissue health, retention, complication rates, and long-term survival.

Conclusion

Evaluation of the marginal and internal fit of implant-supported crowns has progressed from simple visual and sectional methods to sophisticated three-dimensional digital analysis. Conventional methods such as direct microscopy, probing, radiographs, and sectioning remain useful, but each has clear limitations, especially when comprehensive internal evaluation is needed. The silicone replica technique continues to be one of the most practical non-destructive conventional methods, while triple-scan workflows, CAD-based superimposition, and micro-CT represent the most important contemporary advances. Among these, micro-CT offers very high precision for research, whereas triple-scan and related digital methods are especially promising because they combine non-destructive analysis with compatibility with modern digital prosthodontic workflows. CBCT, although valuable for other diagnostic purposes, currently has limited reliability for precise marginal gap evaluation. Overall, the strongest trend in contemporary literature is toward digital, non-destructive, and three-dimensional assessment, particularly for implant-supported crowns where accurate adaptation has major biological and mechanical implications.

REFERENCES:

1. McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an in vivo technique. Br Dent J. 1971;131(3):107-111.
2. Holmes JR, Bayne SC, Holland GA, Sulik WD. Considerations in measurement of marginal fit. J Prosthet Dent. 1989;62(4):405-408.
3. Groten M, Axmann D, Pröbster L, Weber H. Determination of the minimum number of marginal gap measurements required for practical in vitro testing. J Prosthet Dent. 2000;83(1):40-49.
4. Abduo J, Bennani V, Waddell N, Lyons K, Swain M. Assessing the fit of implant fixed prostheses: a critical review. Int J Oral Maxillofac Implants. 2010;25(3):506-515.
5. Son K, Lee S, Kang SH, Park J, Lee KB, Jeon M, et al. A comparison study of marginal and internal fit assessment methods for fixed dental prostheses. J Clin Med. 2019;8(6):785.
6. Di Fiore A, Zuccon A, Carraro F, Basilicata M, Bollero P, Bruno G, et al. Assessment methods for marginal and internal fit of partial crown restorations: a systematic review. J Clin Med. 2023;12(15):5048.
7. Ayres AP, Cuschieri L, Bianchi DM, Pradíes G, Côrtes ARG. Advantages and drawbacks of different methods to measure marginal gaps in fixed dental prostheses: a scoping review. J Dent. 2024;151:105400.
8. Laurent M, Scheer P, Dejou J, Laborde G. Clinical evaluation of the marginal fit of cast crowns: validation of the silicone replica method. J Oral Rehabil. 2008;35(2):116-122.
9. Abduo J. Fit of CAD/CAM implant frameworks: a comprehensive review. J Oral Implantol. 2014;40(6):758-766.
10. Hasanzade M, Shirani M, Afrashtehfar KI, Naseri P, Alikhasi M. In vivo and in vitro comparison of internal and marginal fit of digital and conventional impressions for full-coverage fixed restorations: a

systematic review and meta-analysis. J Evid Based Dent Pract. 2019;19(3):236-254.

11. Mai HY, Lee WK, Kwon TG, Lee DH. Reliability of digital measurement methods on the marginal fit of fixed prostheses: a systematic review and meta-analysis of in vitro studies. J Prosthet Dent. 2020;124(3):350.e1-350.e11.
12. Holst S, Karl M, Wichmann M, Matta RE. A new triple-scan protocol for 3D fit assessment of dental restorations. Quintessence Int. 2011;42(8):651-657.
13. Holst S, Karl M, Wichmann M, Matta RE. A technique for in vitro fit assessment of multi-unit screw-retained implant restorations: application of a triple-scan protocol. J Dent Biomech. 2012;3:1758736012452181.
14. Park JM, Hämmerle CHF, Benic GI. Digital technique for in vivo assessment of internal and marginal fit of fixed dental prostheses. J Prosthet Dent. 2017;118(4):452-454.
15. Hasanzade M, Koulivand S, Moslemian N, Alikhasi M. Comparison of three-dimensional digital technique with two-dimensional replica method for measuring marginal and internal fit of full coverage restorations. J Adv Prosthodont. 2020;12(6):344-350.
16. Moris ICM, Monteiro SB, Martins R, Ribeiro RF, Gomes EA. Influence of manufacturing methods of implant-supported crowns on external and internal marginal fit: a micro-CT analysis. Biomed Res Int. 2018;2018:5049605.
17. Yildirim B, Paken G. Evaluation of the marginal and internal fit of implant-supported metal copings fabricated with 3 different techniques: an in vitro study. J Prosthodont. 2019;28(3):315-320.
18. Kayikci O, Ates SM. Comparison of marginal and internal fit of three-unit implant-supported fixed prosthetic substructures fabricated using CAD/CAM systems. Clin Oral Investig. 2022;26(2):1283-1291.
19. Doriguêtto PVT, Almeida D, Lima CO, Lopes RT, Devito KL. Assessment of marginal gaps and image quality of crowns made of two different restorative materials: an in vitro study using CBCT images. J Dent Res Dent Clin Dent Prospects. 2022;16(4):243-250.
20. Giti R, Farrahi P. Marginal fit of 3-unit implant-supported fixed partial dentures: influence of pattern fabrication method and repeated porcelain firings. PLoS One. 2024;19(4):e0301799.