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Assessment Of Internal Fit And Marginal Discrepancy In Full Ceramic And Metalceramic Dental Crowns - Review Article.

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ABSTRACT

The accuracy of internal fit and marginal precision play important role of clinical quality and success of dental crowns. Complications caused by marginal discrepancies such as caries, gingivitis, hypersensitvity are highlighted in dental literature. Despite marginal fit, internal fit and precision have a significant role in the persistence of full ceramic and metalceramic crowns. As the technology evolves, it's questionable which impression method and method of crown producing is giving most accurate dental crowns. Therefore, the main purpose of this study is to review previous research and data about marginal and internal fitting, different impression techniques (conventional, two-phase impression technique with polyvinyl siloxanes and digital impression using intraoral digital scanner) and manufacturing process.
Keywords: internal fit, marginal discrepancy, metalceramic, full ceramic crowns.

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INTRODUCTION

Precision of internal and marginal fit plays an important role in the accuracy and success of dental crowns [1]. Fixed prosthetic restorations with a poor fitting on prepared tooth are a potential danger, allowing entry and reproduction of oral bacteria that subsequently cause secondary caries and gingivitis[2,3]. Microleakage through dental tubules may lead to pulp inflammation[4,5]. Thus, poor internal and marginal fit of fixed prosthetic restorations, is the reason that reduces their resilience and longevity[6].

For many years dental researchers examine how the crown fits. As technology developed, advances and changes happened also in measuring the fit of dental crowns: direct observation, crown sectioning, replica technique, profilometry, image analysis and 3D scanning[7,8]. Each has advantages and disadvantages, but the visual observation is not valid because of subjectivity and tactile sensitivity of the examiner.

All procedures during the manufacturing of the crown require precision and accuracy in order to produce a restoration that fits.

There are new developments in technology that have changed impression and manufacturing : digital impression and computer-aided design / computer-aided manufacturing system (CAD / CAM).

Dental impressions is one of the key steps for successful prosthetic restoration and they can greatly affect the accuracy of the restoration. The precision of conventional impression depends on the material, type of trays and impression technique that is used.

Dental digital impression systems are growing in popularity, as these high tech systems simplify the impression process, increase accuracy, decrease procedure time and ables digital integration with dental laboratories. Digital impressions eliminate patient's discomfort of using impression materials, and the 3D digital models they create are highly accurate and detailed. The scans are ready almost instantly and can be sent directly to a dental lab or to a chairside CAD/CAM system without the need to pour a model or pay for shipping. These impressions increase patient comfort, decrease clinical errors and reduce the time it takes to complete a case.

The literature demonstrates that multiple all-ceramic materials and systems are currently available for clinical use, and there is not a single universal material or system for all clinical situations. The successful application depends upon the clinician to match the materials, manufacturing techniques, and cementation or bonding procedures, with the individual clinical situation[9,10].

DISCUSSION

INTERNAL FIT AND MARGINAL PRECISION OF PROSTHETIC DENTISTRY DENTAL CROWNS

Poor marginal adaptation of ceramic crowns can damage the tooth, periodontal tissues and the restoration. Large marginal discrepancies result in dissolution of the luting agent and favor microleakage of bacteria and their bioproducts. As a consequence, the tooth becomes more susceptible to inflammation of the vital pulp (post-operative sensitivity), secondary caries and marginal discoloration. Precise adaptation is of great importance for crown longevity[11] . In clinical practice margins of dental crown should be ideally positioned on preparation line, which is hard to achieve and to control it.

Consequences that occur with poorly fitting of dental crown were topics of many authors who have found that microleakage[12,13], caries, hypersensitivity and gingivitis[14] are common complications. A clinical research by Demir N et al. proved that cavities are the most common cause of the failure of the crown[11]. Factors like increased depth preparation seem to cause a bigger marginal gap. Abad-Coronel C.et al. claims that microleakage is the penetration of substances, such as bacteria, oral fluids, molecules, and/or ions, into a gap or a structural defect that is naturally present between restorative materials and tooth structure and damages tissues.[14]

Bader et al. also showed that plaque, gingival inflammation and bleeding were significantly higher in teeth with crowns than without them[2]. Although White et al. report that marginal gap itself is not directly

correlated with marginal microleakage[1] , accuracy of it is estimated as one of the most important criteria for clinical quality and success of prosthetic restorations.

According to Holmes et al. "Fitting of the crown can be measured by measuring the gap between the tooth surface and the interior of the crown[15]. The ADA's (American Dental Association) number 8 specification suggests a maximum cement thickness of 40 μm, but this range is rarely achieved. Classical study of McLean and von Fraunhofer stated that a maximum of 120 μm is clinically tolerable[16]. With new manufacturing techniques, that discrepancy implies a greater challenge for the new materials to seal it. Nawafleh et al. stated there is no conclusive evidence about an optimum fit of contemporary systems, with a diverse range between 7.5 and 206.3 μm.

Several studies have examined adapting of dental crowns and their internal fitting[17,18]. Specifically, Carter SM. et al. informed that the force required to remove the crowns before cementation decreased with increasing layers of die-spacer. Following cementation, the mean crown elevation decreased from 547 micrometers (zero layers) to 38 micrometers (eight layers); while the mean removal force increased from 250 N (zero layers) to 375 N (eight layers)[18]. Olivera AB , researched that increasing the area of the die surface covered with spacer improved the fit of the cast restoration. Resin cement had the highest resistance to tensile forces.[19] Fusayama et al. prooved that a interstitial layer of varnish or a thin film (thickness 40 µm) improves the fitting of dental restoration, regardless of whether they are used entirely or partially[20].

Passon C. et al. confirmed that there were no statistically significant differences ($P > or = 0.05$) between the mean force required to remove the cemented copings. It appears that increasing the application of die-spacer up to 16 coats (151 micrometers) does not adversely affect the retention of cemented cast copings[21]. Results of Lee HH et al. showed that die relief reduced vertical seating discrepancy associated with cementation by up to 79 microns. Differences between paired relieved and unrelieved samples were significant ($p < 0.05$)[22].

METODS FOR ASSESSING THE INTERNAL FITTING AND THE MARGINAL DISCREPANCY OF DENTAL CROWNS

There are several methods that have been discussed in the literature to measure internal fitting and the marginal discrepancy. Such methods include crowns sectioning, replica technique, profilometry, image analysis and 3D scanning.

Primary, the dentist reveals marginal adaptation. Hayashi et al. studied the impact of the researcher and his visual condition in assessment of vertical and horizontal discrepancies[23,24]. Clinical experience had the greatest impact in the identification of gaps.

Crown sectioning is an *in vitro* technique, a classic method of destructive testing as making sections of samples and then analyzing them under optical or electronic microscope[25]. The advantage of this technique is accuracy, precision and repeatability of measurements. But the obvious limitations of this method is the destruction of the samples which creates the need for duplicates.

Radiography can also provide information regarding the marginal fitting of the crown, and again, the important thing is experience and clinical practice of the examiner. Assif et al. made a comparative study between the tactile method, radiography and replica method (using a silicone impression material) to test the marginal fitting[26]. His results showed that by examining the thickness of the silicone layer-replica technique, are getting most accurate results. Researchers used different experimental set-ups and measured the marginal gaps under different conditions. Making the measurement *in vivo* or *in vitro*, before or after cementation[27], before or after veneering, on a chamfer or shoulder finish line, sample size and number of measurement per sample have been found to affect the marginal adaptation. Hence, differences in setting these conditions have led to inconsistencies in the results leading to conflicting conclusions concerning the clinical acceptability marginal fit of specific ceramic systems.

Mohammed M. Beyari, compared marginal and internal crown fit evaluation of CAD/CAM crowns and pressed all-ceramic crown by using stereo microscope. He found significant difference for cement thickness in midaxial, cusp, and occlusal locations within the group and no statistical difference in marginal fit of all-ceramic crowns[28].

Profilometry, is a nondestructive method. It presents the view of both the die and the specimen in the same focal plane on monitor, thus allowing for an accurate focus[29]. However, with profilometry, the thickness of the cement layer at the marginal areas can only be indirectly inferred, and in the case of sequential analysis, extreme care should be taken in repositioning the specimens, otherwise wrong results will occur.

Trifkovic et al. made a comparative study of the measuring values of the marginal gap related to the ceramic crowns made by dental CAD/CAM system using the replica technique and SEM (scanning electron microscopy). The measured values of marginal gaps of ceramic crowns using the replica technique were significantly lower compared to those measured by SEM. The results indicate that the choice of technique for measuring the accuracy of ceramic crowns influences the final results of the study.[30] The authors concluded that the method of measurement depends of the material, and the method of analysis should be standardized .

In the impression replica technique, RT, however, the crown is filled with low viscosity light body silicone material and seated on the die simulating the cementation procedure. After setting of the silicone material, the crown is gently removed from the die, and heavy body silicon is injected inside to stabilize the thin light body film before removing it from inside the crown. The light body silicon layer can then be sectioned and measured with microscope at different sites. Researchers were using RT to measure fitting of the crowns[31], and Boening et al. tested Procera All Ceram crowns this way[32]. The main limitation of this method is distortion, even damage of the material during handling.

Necla et al. evaluated the marginal gap and absolute marginal discrepancy of Feldspathic Cerec inLab ceramic system, full ceramic crowns with two finish line designs, shoulder and chamfer, using microcomputed tomography (micro-CT). It is a computerized microtomography where more projections of the object were made from a source that rotates around it[33]. The projections were transferred to a computer and analized with a special software.

3D method was proposed by Holst et al. for triple scan using non-contact optical scanner. Three scans were made: coping solo, master cast solo and coping placed on master cast in a final position[34]. After digitizing the information of the area, all data were analyzed by software. Disadvantage of this method is the need to prime the translucent surfaces with contrast (full ceramic crowns). Therefore is rarely used because of technical difficulties.

THE IMPORTANCE OF DENTAL IMPRESSIONS IN INTERNAL AND MARGINAL PRECISION OF DENTAL CROWNS

All the steps in the fabrication of crowns require precision and accuracy in order to produce an accurate restoration. Recent advances in technology made changes in impressions and manufacturing, in particular, digital impressions and computer-aided design / computer-aided manufacturing system (CAD / CAM) . Impressions from the hard and soft tissues of the oral cavity is one of the most important steps for successful dental restoration. Over the past few decades, impression materials have changed, so today with the proper selection and manipulation, great impressions can be achieved [35,36]. In addition to impression material, its choice is of great importance. The combination of a proper material, manipulation and knowledge by the dentist gives most accurate results[37] .

Walker et al. assessed detail reproduction of polyether and polyvinyl siloxanes, PVS, by observing the continuous replication of at least two of the three horizontal lines[38]. Impressions were made in dry and wet conditions. They found that in dry conditions all materials provided sufficient detail reproduction at 100% of the time, but in terms of humidity, only 29% of PVS materials provided satisfactory details.

The elasticity of the material is its ability to return to its original dimension when the impression is removed from the mouth. PVS materials have the best elastic recovery of over 99%, which is demonstrated with specific section tests.

Thongthammachat et al. assessed the dimensional accuracy of dental impressions made with different types of trays and materials poured at different times [37]. Researchers conclusion was that the

impressions made from polyether should be poured only once within one day due to instability of the material that occurs over time. The addition impression material has better dimensional stability than polyethers[39].

Reddy NR et al. evaluated the accuracy of dies made from dual arch impressions using different sectional dual arch trays using combinations of elastomeric impression materials. Group I constitute impressions made using monophase impression material, Group II constitute impressions made using combination of heavy body and light body, and Group III constitute impressions made using combination of putty and light body. From the results obtained, dies poured from combination of heavy body and light body impressions using plastic or metal dual arch trays showed least variation in bucco-lingual dimension from master model[40]. Hung et al. announced that the accuracy of addition silicones is more affected by the type of material than the impression technique[41]. The findings of studies suggest that impressions made with conventional trays are as accurate as those impressions made with individual trays.

Padmakar S. Patil et al. evaluated linear dimensional accuracy of polyvinyl siloxane by using custom and stock trays[42]. This study showed that custom trays provide more accurate dental casts than stock trays, but if stock trays are properly oriented, giving uniform impression thickness, they can give better result than custom trays[43]. Among the deviations in this study, all the dimensions of different impression techniques are in the range of clinical acceptability i.e. 90µm. The conclusion in this discussion is that if accurate impression material, good impression protocol and controlled conditions that approximate clinical situation such as oral temperatures are used, a rigid stock tray may be a valid alternative to custom tray [44].

The results of Michael N. Mandikos who researched polyvinyl siloxane impression materials indicate that they produce highly accurate impressions because they reproduce fine surface detail, and have excellent elastic recovery, adequate tear strengths, and exceptional dimensional stability. They are compatible with all common die materials, can be disinfected or sterilized, and can be repoured after delayed periods. If handled appropriately, polyvinyl siloxanes can be applied in almost any indirect procedure[45].

Advantages of digital impressions is that they are accurate, saving time and cost, lab and dentist have better communication as well, comfort and acceptability to patients. Precise and comparative study with intraoral scanners is represented Logozzo et al.[46] and Skotti et al.[47]

In summary, there are materials and techniques used for impressions of a soft or hard oral tissues. All past have advantages and disadvantages, but the knowledge and experience leads to proper selection and successful outcome

MARGINAL AND INTERNAL ACCURACY OF DENTAL CROWNS DEPENDING ON THE TECHNOLOGY TO BE USED

Many materials are used in fixed prosthetics and each has its indications, advantages and disadvantages. Fully ceramic crowns with their aesthetic properties are increasingly demanded by patients, so the biomechanical requirements and longevity should be similar to metalceramic restorations.

Holden et al. was comparing metalceramic crowns, leucite reinforced ceramic pressed to metal and leucite reinforced glass ceramic crown. All crowns were examined microscopically with x45 magnification. The results showed the worst marginal closing is in metalceramic crowns, and most accurate in leucite glass ceramics pressed on metal crowns[48] .

Yeo et al. examined marginal discrepancies in In-Ceram, IPS Empress II and metalceramic crowns, using light microscopy. The results showed the smallest marginal gap in the IPS Empress II crowns, while the largest in metalcermic crowns[49] .

Baig et al. compared the marginal fitting in zirconia (Cercon Y-TZP), IPS Empress II, and metalceramic crowns. The gap was 66.4 µm, 36.6 µm and 37.1 µm, by order. Significantly larger gap in zirconia crown he attributed to distortion in slicing the ceramic block and complicated manufacturing[50] .

Syrek et al. made a comparison between full ceramic crowns made by digital impressions, and full ceramic crowns made by polyvinyl siloxanes impressions [51] . Crowns produced with digital impressions were more accurate than crowns produced with classic method of impressions.

CONCLUSION

Studies have shown that the most accurate marginal fitting have crowns made of leucite reinforced glass ceramic crown, and the largest marginal gap have metalceramic crowns.

About the impressions, there have been some studies if modern, computerized technology can replace the standard impression techniques. Results so far have shown that digital intraoral impressions have an advantage over conventional ones, because of convenience and acceptability to patients and the absence of multiple manipulations that increases the chance of errors.

The type of preparation is contributing to the crown fitting. Preparation is standardized for this type of researching, so finish line is 1 mm wide, rounded shoulder margin with 6 degree inclination of axial walls.

In this review article are written some of the opinions, conclusions and criticisms of researchers working on issues of internal and marginal fitting of dental crowns obtained with different types of impression and different materials.

With the development of technology and new materials in restorative dentistry, studies are being made in order to indicate which are suitable for clinical use, and which are for further research.

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