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Marginal and internal fit of fixed prosthodontic constructions: a literature review

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ABSTRACT

Marginal fit of fixed dental prostheses is determined by the size of the gap between the margin of the restoration and finish line of the prepared tooth. The most important factors influencing marginal and internal fit of fixed dental prostheses are the material used, the type of finish line as well as peculiarities of various technique of restoration fabrication. The objective of the article is to review the literature about the marginal and internal fit of various fixed prosthetic constructions. A review of literature using Pubmed, Google Scholar, and Research Gate database was carried out and 73 articles mostly in English were selected. The keywords were "Computer-aided design, marginal gap, internal fit, marginal fit, and crown adaptation". Clinically accepted boundary value of marginal gap is considered to be $\leq 100 \mu\text{m}$. However, a number of factors such as milling machine, parameters of bur (diameter, sharpness), software, design preparation, smooth preparation margins and incorporation of rounded line angles on the tooth preparation, the type of finish line, material and fabrication method of the construction and type of impression method should be taken into consideration in order to achieve these results. The perfect marginal and internal fit are the guarantee of construction success and longevity. As a sizeable marginal opening concedes more plaque accumulation, gingival sulcular fluid flow and bone loss, following in microleakage, recurrent caries, periodontal disease and a decrease in the longevity of the prosthetics restorations. Currently used techniques of restoration manufacturing, including constructions manufactured by computer aided design/computer aided manufacturing system can provide clinically allowable marginal fit.

Keywords: all ceramic, metal ceramic, marginal fit, marginal gap, internal adaptation

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Introduction

Survival of fixed prosthetic constructions is conditioned by a number of factors the most special and significant of which is marginal and internal fit of restoration^[1-5]. Restoration adaptation might be affected by a number of factors such as design preparation, localization of finish line, restoration material and mold technique, fabrication method, the type of cement, dentist's skills, the type of finish line etc. ^[6-9]. The low sintering shrinkage and porosity are responsible for the perfect adaptation and high strength of the material ^[10]. It should be mentioned, that marginal distortion of metal ceramic restoration can occur at various stages of fabrication. Moreover, metallic margin of metal-ceramic constructions is often visible through the marginal area giving a blue-gray, cyanotic appearance to the tissue ^[11]. The intaglio surface of a crown is important for the retention and resistance of the crown. Rough intaglio surface can hinder the complete seating of the crown leading to an open margin.

Marginal fit is clinically evaluated by probing. Marginal fit can be indirectly assessed radiographically, and through epoxy resin replicas by light and scanning electron microscopy^[12,13]. Despite their wide use, microscopes might result in inaccurate measurement, poor identification of reference points, projection errors and rounding of the margins^[14]. A popular non-destructive method used to assess the marginal and internal fit is the silicone replica technique. A light-body PVS material is used to record the space between the prepared tooth and inner surface of the restoration^[15,16]. Afterwards, silicone film can be measured at different sections - both at the margin and internal walls. This method is easy to perform, is relatively less expensive and is considered to be reliable to assess marginal and internal fit^[17].

The increase in esthetic restoration demand makes all-ceramic restorations of a great importance ^[18,19] since they ensure steady progress providing better aesthetics,

biocompatibility, resistance to discoloration, wear, corrosion and masticatory forces over time^[20-24]. In order to provide clinical success and longevity of various restorations it is necessary to meet mechanical, biological and esthetic requirements. Marginal and internal adaptations are crucial factors, since they deal with the mentioned criteria as marginal integrity, structural rigidity, preservation of periodontal and pulpal health ^[25].

Due to the increased marginal discrepancy the cement makes up a thicker layer which undergoes more influence of the oral cavity environment resulting in cement dissolution which in its turn leads to accumulation of the tooth biofilm, hypersensitivity, marginal discoloration, microleakage, caries, more gingival sulcular fluid flow, pulp infection and eventual bone loss and lesion of periodontium ^[26-32]. Poor internal adaptation can lead to a lack of restoration retention and poor resistance form for the tooth-restoration complex ^[33]. Besides, thick cement layer favors a higher concentration that can lead to microcracks, piece maladjustment and even to marginal fractures of loose ceramic ^[34,35]. In its turn, internal adaptation reflects the fracture force of the prosthetic work. Thus, the thick layer of cement allows a place of force concentration, providing favorable conditions for fracture ^[36].

Various methods to fabricate different types of restorations are described in literature^[37]. Conditioned by the simplification of the clinical and laboratory procedures, wide application of CAD/CAM system has been recently observed among the dentists^[38]. Taking into consideration the importance of marginal and internal adaptation in restorative dentistry, the goal of this study is to analyze and to compare the data on marginal and internal fit of fixed prosthetic constructions in contemporary literature as well as to discover the most acceptable, clinically permissible boundary value of marginal gap.

Material and Methods

A review of literature in the PubMed, Google Scholar, and Research Gate data-bases was

performed with the keywords: computer aided design, marginal gap, internal fit, marginal fit, and crown adaptation. The selection criteria were articles mostly in English that approached the studied theme between 2000 and 2018. Altogether, there were 73 articles selected.

Literature Review

Generally adopted approach to the acceptable value of marginal fit still hasn't been suggested. Some specialists consider the value lower or equal to $120\mu\text{m}$ [39-41] to be acceptable, while others believe it should be less than $100\mu\text{m}$ [42,43] and there are still those who argue, that the acceptable value should range between $20\text{-}75\mu\text{m}$. The latter rarely meets clinical practice, though. The marginal fit promoted by the CAD/CAM system has been studied by various methods and compared in different clinical cases. Marginal and internal adaptation of ceramic inlays fabricated by CAD/CAM system and injection technique were compared in one of the studies. It revealed, that there was a lower marginal maladjustment in those fabricated by CAD/CAM, having no significant difference concerning the internal precision [44]. No significant differences between the marginal fit of onlays fabricated by CAD/CAM or injection were found in another study, while the internal maladjustment of the digital fabricated restoration was higher [45]. No significant difference between marginal fit, both vertical and horizontal, between the lost wax and CAD/CAM methods for total crowns of lithium disilicate was revealed in another research [46]. Though, another research revealed some data on a bigger marginal maladjustment in crown made by the CAD/CAM system [47]. In comparison with metal-ceramic restoration, all-ceramic crowns fabricated by CAD-CAM had lower imprecision [48]. For the CAD/CAM E4D system (E4D Dentist system; D4D Technologies), the best spacing would be of $30\mu\text{m}$ or $60\mu\text{m}$ in terms of marginal maladjustment [49]. However, the spacing of $50\mu\text{m}$ is also supported in literature [50,51]. Despite existing contradiction, the differences

may also be conditioned by the digitalization method of tooth preparation. According to some studies, direct digitalization shows a better result for marginal precision, compared to indirect digitalization, when a conventional mold is done and the plaster model is scanned [52], while no significant differences are reported by other researches [53,54]. There is a study, according to which the mean marginal gap values were $86.64\mu\text{m}$ for CAD/CAM milling, $96.23\mu\text{m}$ for direct metal laser sintering, and $75.92\mu\text{m}$ for traditional casting [55]. A link was determined also between commercial brand of CAD/CAM system and adaptation [56] according to which each brand has its peculiarities of prosthesis fabrication at different stages, which include scanning, design, and milling. Karl et al. [57] investigated the quality of fit of zirconia crowns and they found that monolithic zirconia showed greater passivity of fit than veneered zirconia.

In conventional restorations, finish line also affects marginal fit which ensures certain amount of cement outflow. The beveled shoulder finishing produces a smaller marginal maladjustment, while deep chamfer presents better internal fit [58]. For metal free crowns, two main finish lines i.e. round shoulder and the deep chamfer are suggested [59], while bevel is contraindicated for all ceramic restorations. However, the round shoulder finish line presents better values of a marginal gap than the deep chamfer and the addition of ceramic effect the final gap values of marginal fit [60]. However, no difference among the group of teeth that received a shoulder finishing and the other group, in which a shoulder finishing was made in the vestibular wall associated with chamfer in the proximal and lingual walls is observed in another research [61]. Some researchers assessed also the changes in the marginal fit, which takes place at different stages of fabrication [62]. A study revealed, that at different stages of fabrication, differences in marginal fit were observed in the chamfer group ($p=0.0042$) but there were no differences in the

crowns with shoulder margins ($p=0.4335$) [63]. The marginal discrepancy in the rounded shoulder group was significantly lower than that in the large chamfer and tilted chamfer groups, whereas the rounded shoulder had the greatest internal discrepancy and large chamfer group had the least values ($p=0.0014$) [64]. One of the advantages of CAD/CAM that should be noted is the fact that it allows to make temporary restorations which have better adaptation than the ones manufactured by conventional method [65].

Within the recent research [66] metal ceramic and all ceramic restorations studied were divided into 6 groups and marginal fit of the constructions was assessed. Restorations were manufactured by various methods. Group A: Conventional wax up method used to producing wax copings and then converted to metal copings by lost wax technique. Porcelain layering done and then shoulder porcelain. Group B: in this group wax copings made from CAD/CAM able wax blocks and converted to metal copings by lost wax technique and then

porcelain layering and adding shoulder porcelain done like group A. Group C: in this group sintron technology used. Copings were milled from soft presinterd chrome cobalt alloy by CAD/CAM and then sintered in special oven under pressure of argon gas. Final strength of these copings is comparable with conventional method. Adding porcelain steps are like group A. Group D: Restorations of this groups were lithium disilicate (e. max-press). First a full contoured wax up performed. After lost wax technique e max ingots pressed to the mold space by special plunger. Finally, a full contoured all ceramic restoration produced. Group E: Restorations in this group were named zircon. Zircon core milled by CAD/CAM from pre-sintered zirconia blocks. Then sintered and porcelain layering done. Group F: restorations in this group named Zolid. Full contoured restoration milled from pre-sintered zirconia blocks by CAD/CAM and then sintered in special oven. As a result, the following data on the marginal fit were obtained: (Table 1,2)

Table 1. Marginal gap measurement data (expressed in μm) in all groups

Group	Mean±SD	Min	Median± IQR
A	135.4±69.3	49.8	106.9±86.7
B	92.5±54.8	39.1	72.8±35.7
C	195.2±123.3	54.3	152.4±142.0
D	155.9±73.7	69.5	136.7±63.7
E	181.0±85.5	65.2	176.9±69.07
F	168.7±45.1	87.6	165.0±56.4

Table 2. Marginal gap measurement data (expressed in μm) in metal-ceramic and all-ceramic groups

Group	Mean±SD	Min	Median±IQR
Metal ceramic	141.0±96.9	39.1	105.9±99.3
All-ceram	168.6±70.7	65.2	155.5±68.8

There is an opinion, that restoration precision has significantly improved since CAD/CAM systems were introduced in dentistry. Preparation of the teeth for CAD/CAM is more critical than for injection technique, since they can create imprecisions during the milling [67] due to the drill size. Thus, is it very important for the prepared tooth to have rounded angles and smooth walls [68]. Adaptation differences of restorations fabricated by CAD/CAM or injection technique depend on the different phases each process includes. While analyzing restoration overlapping, other factors should be also taken into account. These factors can be conditioned by the system itself, since many successive phases can result in imprecisions, including scanning, digital margin localization, design software and milling [69]. Even the size of milling drill used will interfere on the ability of copying the details of the pieces, [70] besides that the milled material affects the milling precision. Harder materials, such as titanium and densely sintered zirconia, require more strength and make the drill more susceptible to mistakes, so the drill should always be sharp [71].

The data contained in the articles cannot be made comparable, which is due to the fact that the results have been obtained using a variety of research methods [72]. Prepared tooth design, localization and number of the maladjustment measure points, kind of resinous cement, measurement technique and method of restoration fabrication are directly related to marginal discrepancy value found [73]. Reported marginal fit was inside the acceptable clinical parameters, considering it as below $100\mu\text{m}$. Despite having many in vitro studies on the theme, it is necessary to carry out further clinical investigations and to do a long-term follow-up to try to associate these values found with a clinical correlation of restoration durability.

Conclusion

The data presented in the review revealed that all the investigations with their results obtained are extremely contradictory which excludes any

probability of them being comparable and limits any possibility of making ultimate conclusion. However, it can be confidently stated that marginal fit affects the clinical success and longevity of restoration, and the type of the finish line is a crucial factor affecting the marginal fit of fixed prosthetic constructions. Regardless the type of cement, large gaps contribute to its dissolution. Other significant factors which have their impact on marginal fit are the material of the construction, method of fabrication, peculiarities of tooth preparation as well as the dentist's experience and skills which are important from the point of view of the necessary adjustments at the stage of clinical trial of restorations. Currently used methods of restoration fabrication, including constructions fabricated by CAD/CAM system can ensure clinically acceptable marginal fit. Nevertheless, CAD/CAM system with its marginal and internal adaptation with its precision and perfection hasn't yet reached the level which would allow to quit conventional technique.

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