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Monografia de Investigação/ Relatório de Atividade Clínica

Mestrado Integrado em Medicina Dentária

Faculdade de Medicina Dentária da Universidade do Porto

Marisa Oliveira Furtado

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**Autor:** Marisa Oliveira Furtado

Aluna do 5º ano do Mestrado Integrado em Medicina Dentária da  
Faculdade de Medicina Dentária da Universidade do Porto

**Orientador:** Professora Doutora Ana Isabel Pereira Portela  
Professora Auxiliar do Mestrado Integrado em Medicina Dentária da  
Faculdade de Medicina Dentária da Universidade do Porto

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## Resumo

**Introdução:** Desde a sua introdução, os materiais restauradores de resina composta têm sofrido um grande desenvolvimento. Apesar disso, a sua esperança média de vida é de, apenas, dez anos. Facto que está relacionado com a presença de metacrilatos que causam contração de polimerização, podendo levar a infiltração marginal e citotoxicidade. Com o intuito de contrariar este fenómeno, surgiu, recentemente, uma cerâmica organicamente modificada, chamada Ormocer que combina a dureza do vidro com as propriedades da resina. Admira Fusion (VOCO), um Ormocer nanohíbrido universal, reivindica ter a contração de polimerização e o stress mais baixos de todas as resinas compostas disponíveis no mercado. No entanto, a sua maior vantagem é a ausência total de monómeros convencionais na sua composição, diminuindo os riscos associados à biocompatibilidade.

**Objetivo:** Pretendeu-se com esta revisão avaliar se a resina composta Admira Fusion (VOCO) tem vantagens sobre as resinas compostas convencionais à base de BisGMA e se outros materiais similares estão a ser investigados.

**Materiais e Métodos:** A pesquisa foi feita usando as bases de dados PubMed/MEDLINE, EBSCO, B-on, Science Direct e ResearchGate.

**Desenvolvimento:** Vários estudos demonstraram que a resina composta Admira Fusion (VOCO) é considerada menos citotóxica do que outras resinas compostas, porque elui/liberta menos monómeros. Além disso, apresenta menos rugosidade superficial sem qualquer tipo de técnica de acabamento/polimento, mas é suscetível à mudança de cor durante o tempo. Em relação à resistência à fratura, não apresentou pior resistência, em comparação com as outras resinas compostas. Finalmente, ensaios clínicos demonstram que esta resina tem um bom desempenho e comportamento clínicos.

**Conclusão:** A resina composta Admira Fusion (VOCO) é um novo material restaurador promissor. Contudo, são necessários mais estudos de forma a avaliar outras propriedades, especialmente o seu desempenho em ensaios clínicos.

## Palavras-Chave

“Methacrylate free resin composite”, “Dimethacrylate-based composites cytotoxicity”, “BisGMA”, “Silorane composite resin”, “Ormocer”, “Ormocer Cytotoxicity”, “Admira Fusion” e “Admira Fusion Cytotoxicity”.

## Abstract

**Introduction:** The composite resins' restorative materials have been suffering a big development since their appearance. In spite of all these, their average life expectancy is only about ten years. This is related to the presence of methacrylates that cause polymerization contraction and can lead to marginal leakage and cytotoxicity effects. In order to countermeasure this, an organically modified ceramic, called Ormocer has recently emerged. It combines the hardness of the glass with the properties of the resin. Admira Fusion (VOCO), an universal nanohybrid ormocer, is claimed to have lower polymerization shrinkage and stress comparing to other composite resins found on the market. However, the real benefit is the total lack of conventional methacrylate monomers in its composition, which avoids the risks associated with biocompatibility.

**Objective:** The objective of this review is to evaluate if Admira Fusion (VOCO) has any advantages over conventional BisGMA composite resins and if other similar materials are being investigated.

**Materials and Methods:** The research was done using the PubMed/MEDLINE, EBSCO, B-on, Science Direct and ResearchGate databases.

**Development:** Several studies have proved that Admira Fusion (VOCO) is considered less cytotoxic than other composite resins that exists on the market, because it elutes less monomers. Besides this, presents less surface roughness without any kind of finishing/polishing technique. On the other hand, it is susceptible to color change during time. Concerning fracture resistance, Admira Fusion did not exhibit worst resistance, when compared to the other composite resins. At last, clinical trials demonstrate that Admira Fusion has a good clinical performance and behavior.

**Conclusion:** Admira Fusion is a promising new material, however more studies are necessary to evaluate other properties, especially in clinical trials.

## Key Words

“Methacrylate free resin composite”, “Dimethacrylate-based composites cytotoxicity”, “BisGMA”, “Silorane composite resin”, “Ormocer”, “Ormocer Cytotoxicity”, “Admira Fusion” and “Admira Fusion Cytotoxicity”.

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## Introduction

The composite resins' restorative materials have been suffering a big development and a remarkable improvement since their introduction on the market, and they are already a great alternative to replace amalgam due to greater preservation of dental structure, better aesthetics, lower cost and good clinical behavior.<sup>(1, 2)</sup> All of this was achieved through the improvement of the inorganic composite portion, through the introduction of micro and nanohybrid formulas that allowed wear-resistant and aesthetic restorations. So, even in extensive posterior restorations, they are first choice materials due to their good clinical performance.<sup>(1)</sup>

In spite of this, there are still many problems regarding the use of composite resins. The presence of conventional methacrylates, such as Bisphenol-A-glycidyl dimethacrylate (BisGMA), Triethyleneglycol-dimethacrylate (TEGDMA), 2-Hydroxyethyl-methacrylate (HEMA), Ethoxylated bisphenol-A dimethacrylate (BisEMA) and Urethane dimethacrylate (UDMA), in the restorative materials increase the shrinkage stress, which can lead to oral leakage and fractures in many restorations.<sup>(3, 4)</sup> The shrinkage stress results in debonding and marginal leakage into gaps, that affect the stability of restorations, allowing the passage of fluids and salivary proteins that can contribute to secondary caries and biofilm accumulation. This is very often related to the high viscous solubility and low wettability in dentin of the hydrophobic BisGMA monomer.<sup>(5)</sup> Besides this, and because the polymerization of the dimethacrylate composite resins is never complete, it allows around 10% of the groups to diffuse in the oral cavity. Clinical studies have shown that this leakage might induce local and systematic effects, through the penetration in the extracellular and intracellular spaces. For example, it has been proved that TEGDMA can induce erosion, enzymatical hydrolytic disintegration, alcoholysis and contribute to the release of degrading products. HEMA inhibits intracellular tyrosine phosphorylation and cell growth, interferes with the expression of type I collagen by gingival fibroblasts and promotes its deterioration, causing a cycle perturbation and inducing apoptotic cell death. Therefore, the methacrylates may reduce cellular proliferation and induce cellular mutations that can cause damage in the DNA.<sup>(6, 7)</sup> So, there is growing evidence that BisGMA and the other methacrylates may adversely affect humans.<sup>(8)</sup>

That said, the evolution of restorative materials has been and it's still remarkable. In regards to the inorganic component, this started by creating Microfill resin composites,

in which, to enhance higher filler levels, they had monomers highly filled with colloidal silica particles that were polymerized through heat. These provided a good polishing, but had low mechanical resistance, being mainly advised for aesthetic areas. In order to overcome this, the Midifill resin composites were introduced, which, in addition to silica, contained glass, that increased the resistance to fracture, allowing its use in not very extensive posterior restorations. Over the years, aesthetic demand has led to search for composite resins with increasing smaller particles and an ability to resist to the occlusal forces. Therefore, Microhybrid compounds and Nanohybrid materials were created and denominated universal (suitable for both anterior and posterior restorations). Also, Nanofill resin composites were introduced, consisting of particles between 5nm and 100nm. A fact that granted them a huge aesthetic.<sup>(1)</sup>

While the evolution of the restorations kept advancing, being its focus the development of an organic matrix, based exclusively on methacrylates such as BisGMA, TEGDMA, HEMA, BisEMA and UDMA, the need to increase the lifetime of these restorations in the mouth was clear. The polymerization shrinkage stress, influenced by the chemical composition of the resin matrix, causes fractures in many of them.<sup>(4, 9)</sup> In addition to this, the unpolymerized components, such as HEMA, BisGMA, and oligomers, are prone to leaching the oral environment, which leads to cytotoxicity effects.<sup>(7)</sup> All this led to the introduction of alternative monomers based on higher molecular weight that allowed an effective reduction of the stress *in vitro*. However, this reduction has not been demonstrated in clinical studies, perhaps due to its multifactorial nature, because all this depends, not only on the material used, but also on the technique practiced by the clinician.<sup>(4)</sup>

Thus, in an attempt to decrease the number of steps required during the restoration process, the Bulk-fill composite resins, with low viscosity, have emerged and are applied in a single layer. Although *in vitro* studies demonstrate that they are advantageous, clinical studies do not show any advantage over conventional composites.<sup>(2)</sup> With this in mind, the researchers went even further and the Self-adhesive composites emerged in an attempt to eliminate the most sensitive step of the restorative technique, the application of the adhesive. These types of resin composites have low viscosity and are more suitable for small cavities, not demonstrating any greater advantages over the existing materials.<sup>(1)</sup>

Despite all these improvements, the average life expectancy of a composite restoration is only about ten years.<sup>(4)</sup> This problem is mainly reflected in posterior



restorations due to secondary caries, fractures of the restoration, marginal infiltration and color alteration, problems that have been related to the stress caused by the polymerization contraction.<sup>(2)</sup>

In order to countermeasure this, methacrylate free composite resins have emerged, with their aim being to increase the biocompatibility and reduce the shrinkage stress. In 2007, a methacrylate free composite resin based on silorane monomers was introduced, in which the polymerization contraction is low (under 1%) and its insolubility prevents leaching the oral environment. Therefore, the stability of the restorations is acceptable and shows a good performance.<sup>(3, 6)</sup>

More recently, an organically modified ceramic, called Ormocer, was presented. With an inorganic base of silicon dioxide and polymerizable organic compounds, it combines the hardness of the glass with the properties of the resin. The aim of this material, which has the color of the tooth, is to improve not only the aesthetics, but also the resistance to abrasion, allowing a decrease in the polymerization shrinkage and roughness of the surface, as well as protection against caries. Additionally, as it lacks BisGMA and any other kind of conventional methacrylates, it avoids any type of concern related to cytotoxicity, being considered inert and improving the biocompatibility.<sup>(10)</sup>

Accordingly, this review focuses on figuring out if the new restorative material, Admira Fusion (VOCO), an universal nanohybrid ormocer, really has advantages over the conventional BisGMA composite resins and if other similar materials are being investigated.

## Materials and Methods

The research was done using the PubMed/MEDLINE, B-on, EBSCO, Science Direct and ResearchGate databases and the following keywords: “Methacrylate free resin composite”, “Dimethacrylate-based composites cytotoxicity”, “BisGMA”, “Silorane composite resin”, “Ormocer”, “Ormocer Cytotoxicity”, “Admira Fusion” and “Admira Fusion Cytotoxicity”.

In this review only studies from the last 10 years were indexed. The inclusion criteria for this search were: *in vivo* and *in vitro* studies and in English, Portuguese and Spanish language. Additionally, the relevant articles obtained were thoroughly read to find any pertinent information related to the theme. In the end, thirty-three studies were selected.

## Development

The composite resins' restorative materials have been suffering a huge development. Nowadays, considering their organic matrix, exists four types of composite resins: 1- methacrylate based composite resin; 2- silorane: ring opening epoxide; 3 – ormocer: inorganic matrix; and 4 – compomer: acid modified methacrylate.<sup>(9)</sup>

The most used composite resins are constituted by methacrylates, that create disadvantages on the restorative materials and lead to problems and side effects in a restoration.<sup>(1, 2)</sup> These effects are mainly related to the presence of methacrylates such as BisGMA and TEGDMA, which can cause cytotoxicity effects and polymerization shrinkage stress.<sup>(4, 7)</sup>

Due to these unwanted effects, a new type of composite resins that came to change everything have emerged, since they don't have conventional methacrylates on their composition. This lack of monomers allows the contraction during the polymerization to be between 1% and 5%. Besides this, it increases the biocompatibility, preventing any cytotoxic effects.<sup>(6, 7)</sup>

The stress produced during polymerization depends on many factors, like resin matrix formulation, quantity of filler used in the composite resin and degree of conversion.<sup>(6)</sup> However, the main factor that influences the polymerization shrinkage is the chemical composition of the resin matrix. That's the reason why researchers changed the matrix composition through the replacement of the methacrylate monomers.<sup>(9)</sup>

One example of free methacrylate composite resins is the one based on silorane, the Filtek P90/Silorane (3M). This type of resin reduces polymerization shrinkage below 1%, through a ring-opening technology, allowing lesser microleakage than the composite resins with methacrylates. Several studies proved that the silorane resin composite has a great marginal sealing.<sup>(9)</sup> Bachi A. *et al* evaluated, *in vitro*, the polymerization stress, shrinkage, bulk and elastic modulus resulting from composite resins. In the end of the study, they concluded that Filtek Silorane presented the lowest shrinkage/stress among the methacrylate-based composites. This is due to a correlation between higher elastic and bulk modulus with increased shrinkage and stress, that appears in the other composite resins.<sup>(11)</sup>

The focus of this review was the study of a type of composite resin Ormocer, called Admira Fusion (VOCO).

Admira Fusion (VOCO) and its bulk-fill version (Admira Fusion x-tra (VOCO)) are Ormocers, organically modified ceramics with a hybrid molecular structure, that combines the hardness of the glass and the properties of the resin.<sup>(10)</sup> That being, Admira Fusion (VOCO) is presented as the first purely ceramic-based restorative material.<sup>(12)</sup> A solution and gelation process (sol-gel method) induces polymerization of multifunctional urethane and thioetheroligo(meth)acrylate alkoxy silanes, to produce silica glass by hydrolysis of the alkoxy groups. This process results in a matrix of long inorganic silica chains with organic lateral chains.<sup>(13)</sup> So, this nanohybrid restorative material combines organic and inorganic components at a nanoscopic scale. Therefore, it contains inorganic-organic copolymers and inorganic silanated filler particles, being described as three-dimensionally cross-linked copolymers.<sup>(14)</sup> Admira Fusion (VOCO) is constituted by inorganic silicon dioxide and polymerized organic units, like zirconium dioxide ( $ZrO_2$ ) and silicon dioxide ( $SiO_2$ ).<sup>(10)</sup> The filler particles have  $1\mu m$  of size and this material presents 84% of inorganic fillers.<sup>(13)</sup>

Admira Fusion (VOCO), basically, consists of ceramic polysiloxane, which has low shrinkage (1,25%) compared to the organic dimethacrylate monomer matrix seen in other composite resins. This type of ormocer improves aesthetics, biocompatibility, abrasion resistance, protection against caries and reduces polymerization shrinkage and surface roughness.<sup>(15)</sup> It also avoids any concerns regarding cytotoxicity associated with conventional monomers, such as BisGMA and TEGDMA. A fact that proves to be a great advantage when compared to methacrylate-based composite resins. The lack of cytotoxicity is due to absence of conventional dimethacrylate monomers and due to a non-react  $C=C$  group in the end of the resin matrix. So, it is considered inert and improves the biocompatibility.<sup>(13, 16)</sup>

The use of Admira Fusion (VOCO) is recommended in: class I to V restorations, as a basis in class I and II cavities, deciduous teeth restorations, reconstruction of anterior teeth, fissure sealing, composite inlays, faceting of discolored anteriors, correction of shade and shape to improve aesthetics, core build-up, locking and splitting of loose anteriors and repair veneers, enamel defects and temporary C and B materials. However, the manufacture VOCO suggests some precautions for its use. Admira Fusion (VOCO) shouldn't be used in individuals with allergies to methacrylates and butylated hydroxytoluene. Not only that, but phenolic substances interfere with light curing, so cements or other materials that contain eugenol should be avoided. At last, this ormocer

is available in the tooth color and in restorative and flowable forms, it is easy to use and it is compatible with all conventional bonding agents.<sup>(12)</sup>

During this review, every aspect of this composite resin will be investigated in order to figure out their real benefits.

### **Biocompatibility**

The lack of conventional methacrylates and, consequently, of cytotoxic effects is one of the great advantages of Admira Fusion (VOCO). This type of ormocer increases the biocompatibility of restorations. With this in mind, Schubert A. *et al* performed an *in vitro* study to compare the cytotoxic effects of Admira Fusion (VOCO) to a nanohybrid composite resin and a nanofiller one, on the standard dermal mouse fibroblasts and human gingival fibroblasts. They arrived to the conclusion that Admira Fusion (VOCO) was significantly less cytotoxic than the other composite resins to both standard mouse dermal fibroblasts and human gingival fibroblasts. Thus, due to the absence of cytotoxic matrix monomers, this ormocer owns, *in vitro*, a higher biocompatibility and reduced adverse biological reactions.<sup>(17)</sup> Also, Yang Y. *et al* investigated the cytotoxicity and induction of double-strand breaks in DNA by dental composite resins, through the monomer's elution. Four microhybrid composite resins, one multihybrid and one ormocer (Admira Fusion, VOCO) were evaluated *in vitro*. Two of the four microhybrid composite resins induced significantly higher double-strand breaks in DNA, justified by the quantity of TEGDMA released by the investigated composite resins. All the others, showed no significant differences and no cytotoxic effects. Hence, Admira Fusion (VOCO) showed great biocompatibility.<sup>(18)</sup>

### **Polishing and Finishing Procedures**

Polishing and finishing procedures are mandatory to the quality of the restoration. When made correctly, they prevent surface roughness and increase aesthetics. A well-polished surface reduces dental plaque and allows good aesthetics. The quality of polishing is affected by the material used for the restoration and the polishing and finishing procedures adopted. The restorative materials are constituted by different particles with different sizes and different hardness, so they wear down differently. As a result, certain polishing techniques may be more suited to specific materials.<sup>(19, 20)</sup>

Beltrami R. *et al* performed an *in vitro* study to evaluate the color stability after polishing and finishing procedures. In the absence of any polishing/finishing procedures, Admira Fusion (VOCO) recorded the lower staining. However, after different finishing/polishing procedures, this ormocer showed a bigger color change than other composite resins. This is probably due to different particle sizes.<sup>(19)</sup> Colombo M. *et al* conducted an *in vitro* study to evaluate and compare the surface roughness of six aesthetic restorative materials after finishing and polishing techniques. This study demonstrated that tungsten carbide burs were the best method to achieve a polished surface. However, as in the previous study, Admira Fusion (VOCO) presented less surface roughness without any kind of finishing/polishing technique. Moreover, the surface roughness increased with the finishing/polishing techniques, a fact that can be also explained by the filler particle size.<sup>(20)</sup>

### **Surface Roughness and Color Stability**

Besides the polishing and finishing procedures, surface roughness, after toothbrushing and simulated mastication, is an important factor to decide which composite resin is best to use in a restoration. The surface gloss is a very relevant factor to esthetics, but the accumulation of dental plaque and bacteria increases surface roughness, which leads to a poor visual appearance. It has been reported that composite resins containing smaller filler particles and spherical ones show less reduction in gloss and less increase in surface roughness compared to those that contain larger irregular fillers. O'Neil C. *et al* performed an *in vitro* study to realize the effect of tooth brushing on the gloss and roughness surface of five bulk-fill composite resins compared to the conventional ones. Admira Fusion X-tra (VOCO), a bulk-fill composite resin based in ormocer technology, appears to have the roughest and the least glossy surface. This is probably due to the presence of clumps of precondensed inorganic filler, that were visible on the surface after the resin had been brushed.<sup>(13)</sup> Augusto M. *et al* realized an *in vitro* study to understand the whitening effects of toothpastes in wear and surface roughness of Admira Fusion (VOCO) and methacrylate composite resins. They concluded that, in the wear factor, Admira Fusion (VOCO) didn't present any differences, but, in the roughness factor, it presents the highest value. This is due to the bonding between the silane molecule (inorganic group) and the polymerizable organic group. The inorganic portion

makes the oligomer more rigid, thus increasing the stress between the polymer and filler interface.<sup>(21)</sup>

The esthetic of a restorative material is a crucial property, being a huge disadvantage the staining and the discoloration that happen during time. The discoloration can be extrinsic or intrinsic and depends on environmental factors. Beverages like tea, coffee or red wine and habits like smoking and poor oral hygiene are associated to staining composite resins.<sup>(22, 23)</sup> Poggio C. *et al* realized an *in vitro* study comparing the color stability of different esthetic restorative materials (one microfilled composite resin, one nanofilled composite resin, one nanoceramic composite resin, two microfilled hybrid composite resins, one nanohybrid ormocer based composite resin and one supra-nano spherical hybrid composite resin) after four weeks of exposure to different solutions. Admira Fusion (VOCO) was the material that suffered less color change when exposed to coffee and the one that presented more staining with red wine. The differences found in color stability between different composite resins can be explained by their different material composition.<sup>(22)</sup> Also, Ceci M. *et al* performed an *in vitro* study to evaluate the color changes after 28 days using one microfilled flowable composite resin, one nanofilled composite resin, one nanohybrid composite resin, one microfilled composite resin, and one nanohybrid ormocer-based composite resin. In this study, Ceram-X Universal and Admira Fusion (VOCO) showed similar results, thus demonstrating the lowest color variation. These two different nanohybrid composite resins demonstrated lower staining susceptibility when compared to the other materials tested. These results are justified by the concept that greater amount of resin matrix results in greater water sorption, which leads to a higher pigment penetration in the microfilled composite resin. So, composite resins with lower amount of inorganic fillers present a higher color change. Also, the higher staining in the nanofilled composite resin is due to the presence of methacrylate monomers that are vulnerable to water degradation.<sup>(23)</sup> Llena C. *et al* realized an *in vitro* study to evaluate the color stability of two nanohybrid resin-based composite resins, two ormocers and a compomer, tracking their immersion during four weeks in four common drinks (water, cola, red wine and coffee). All the solutions produced darkening beyond acceptable limits, being Admira Fusion (VOCO) one of the most affected. This was a surprise, given that Admira Fusion (VOCO) is not an intrinsically hydrophilic. However, it could be explained by inadequate integration between the prepolymerized microfiller particles and the siloxane ones. If the interphase isn't correctly integrated and silanized with the resin matrix, it will allow the infiltration

of water and coloring agents. The beverage that produced more staining was red wine.<sup>(24)</sup> An *in vitro* study conducted by Mailart M. *et al* compared the color stability of bulk-fill composite resins with conventional ones. The conclusion is that Admira Fusion X-tra (VOCO) and GrandioSO proved to have the highest color stability. Authors explained these results through lower organic matrix content and higher inorganic filler content, which leads to lower water sorption. Not only that, but the organic matrix may also be related to staining properties due to the methacrylates presence, which helps corroborate the conclusion of this study.<sup>(25)</sup> Thus, in matters of color change it is important to notice that there are limitations in *in vitro* studies, but Admira Fusion (VOCO) presents a stable behavior during time.<sup>(23)</sup>

### Fracture Resistance

The fracture resistance of a composite resin is very important to increase its time in the oral cavity. Acidic beverages and polymerization shrinkage can produce erosion and undermine the composite resins, which can reduce the microhardness of the material. The erosion and the stress may create space to bacterial accumulation and lead to secondary caries or even to the fracture of the tooth.<sup>(14, 26)</sup> Poggio C. *et al* performed an *in vitro* study to evaluate the microhardness of restorations after immersion in acidic drinks for seven days. Every restoration suffered with the acid. The erosion caused substance loss and surface degradation and it reduced the resistance to abrasion. Admira Fusion (VOCO) offered good initial microhardness and did not show significative microhardness loss after one week. The results of microhardness measuring are justified by the nature of its filling, the lowest being the microfilled hybrid composite resin.<sup>(14)</sup> With the same goal, Yarmohamadi E. *et al* performed an *in vitro* study to evaluate cuspal deflection and microleakage of mesio-occlusodistal cavities restored with three different bulk-fill composite resins. Cuspal deflection depends on size and shape of the cavity, properties of the restorative material and the bonding used system. In this study, maximum cuspal deflection was found in Filtek P60, which is in line with other studies results. This result is probably due to the presence of TEGDMA, because this methacrylate increases shrinkage. On the other hand, the cuspal deflection was much lesser in the teeth restored with Admira Fusion x-tra (VOCO), which is attributed to the presence of inorganic nanofillers (84%) and the total lack of conventional methacrylates that leads to better adaption and less shrinkage.<sup>(26)</sup> McHugh L. *et al* realized another *in*



*in vitro* study to evaluate the cuspal deflection and microleakage of mesio-occlusodistal cavities in third molars restored with different materials. Their first conclusion was that conventional composite resins had more cuspal deflection than bulk-fill resins. Their second conclusion was that, for the conventional composite resins, Admira Fusion (VOCO) had significantly the lowest microleakage scores, while, for the bulk-fill resins, Admira Fusion x-tra (VOCO) had the lowest microleakage. The literature suggests that this is due to higher light penetration in Admira Fusion x-tra (VOCO), compared with the other composite resins. Besides this, it is also possible, that the used adhesive system is more compatible with the Admira composite resin family, since it is manufactured by the same brand (VOCO).<sup>(27)</sup> Also, Canceill T. *et al* performed an *in vitro* study to verify the integrity of the interface using Admira Fusion x-tra (VOCO) in comparison to other bulk fill packable composite resins. In the end, this type of ormocer exhibited a better leakage and an excellent behavior regarding the polymerization contraction and thermal expansion. Results that can be explained by the low shrinkage of this ceramic polysiloxane.<sup>(28)</sup> Another *in vitro* study was performed by Politi I. *et al* to evaluate cuspal deflection and microleakage. For that, they used class II cavities in third molar teeth and modified the resin-based composite restoration protocol using conventional composite resins or their bulk-fill counterparts. The results were clear. There were no significant differences between the conventional Admira Fusion (VOCO) and Tetric EvoCeram or their bulk-fill composite resins, for cuspal movement. However, for microleakage, it was evident that Admira Fusion (VOCO) or its bulk-fill version presented lesser microleakage than Tetric EvoCeram. This fact was explained by the compatibility that exists between the adhesive system and the ormocer used. It was also clear that the teeth restored, using the modified protocol with bulk-fill resin (three increments), presented a lesser mean of total cuspal movements and microleakage, compared with the teeth restored with the conventional composite resins protocol. This conclusion was expected, since the technique used with oblique increments allowed contact with a maximum of one cusp at a time with no constraints on the system.<sup>(29)</sup>

### **Marginal Sealing Ability – Ormocer bond strength**

The composite resin adaptation to the cavity walls is determined by the efficacy of the bonding agent used and the behavior of the material during polymerization. Bonding composite resins to enamel is a well-established clinical procedure, however the

bonding to dentin is more difficult and less reliable. So, the marginal adaptation of restorative systems is an important factor to predict the long-term behavior.<sup>(30)</sup> El-Askary *et al* conducted an *in vitro* study to evaluate the repair bond strength of Admira Fusion (VOCO) using different bonding protocols and times. The results proved that both, time and conditioning method, influenced the ormocer bond strength. First, it was proved that rough and irregular surfaces are better, because they increase mechanical retention. Admira bond adhesive resin proved to be the worst bonding agent due to its high viscosity that does not allow its diffusion. However, Cimara adhesive system (VOCO) lead to a thick adhesive layer, that absorbed the stress and increased the bond strength. In the end, most failures were adhesive and no cohesive, suggesting that Admira Fusion (VOCO) is a good restorative material.<sup>(16)</sup>

### **Clinical Performance**

To verify the real effects/benefits of the ormocer restorative material more *in vivo* studies are necessary. A direct correlation between *in vitro* and *in vivo* studies can hardly be made. The three-dimensional configuration of a prepared tooth is totally different from the flat surfaces used to tests *in vitro*. In addition, the bonded interface is subjected to more stress and challenging situations in the *in vivo* studies.<sup>(23)</sup> A case report with direct placement of Admira Fusion (VOCO) and Admira Fusion X-tra (VOCO) on teeth 46 and 47, in 71-year-old female with was reported. These teeth presented minimal coronal structure and mesio-occlusodistal cavities were restored. In the end, the restorations presented a great esthetics. So, Admira Fusion (VOCO) has the ability to function without heavy investment.<sup>(31)</sup> Albuquerque E. *et al* conducted a randomized clinical trial to evaluate the performance, after six months, of a new universal adhesive system (Futurabond U (VOCO)) when applied using different strategies. The conclusion was that, when this new adhesive was associated to Admira Fusion (VOCO), it presented a good clinical behavior after six months, independently of the bonding strategy employed. The only plausible explanation for the lower percentage of marginal adaptation problems was the Admira Fusion (VOCO) presentation in caps and its directly application into the cavity.<sup>(32)</sup> Hakim F. *et al* presented a case report of two restorative procedures using an ormocer composite resin (Admira Fusion (VOCO)). The first was a 29-year-old woman, that wanted to increase the upper central incisors after the orthodontic treatment. One year

later, the restorations showed shade retention, great marginal integrity and high polish. The second was a 37-year-old woman that came to an appointment with a mesio-occlusodistal fracture on teeth 15, that needed to be repaired. After 8 months, the restoration presented no marginal breakdown, excellent polish, shade retention and no signs of wear. So, these cases, demonstrate that Admira Fusion (VOCO) offers high esthetics and polishability and low wear and shrinkage to posterior and anterior restorations.<sup>(33)</sup>

### **Limitations of Admira Fusion (VOCO) and Future Investigations**

During this review it was clear that, despite the manufacture having announced that Admira Fusion (VOCO) doesn't have any conventional methacrylates on its composition, this new ormocer material has other kind of monomers. This fact is explicit in the precautions of Admira Fusion (VOCO), where it is pointed out that, in patients with hypersensitivities to methacrylates, the teeth shouldn't be restored by this material. Further investigations on Admira Fusion (VOCO) are essential. First, it is necessary to figure out the type of methacrylates that constitute Admira Fusion (VOCO). Then, more clinical trials and *in vivo* studies are clearly needed to really evaluate this material, not only to evaluate the biocompatibility, but also all of the other properties.

Besides this, a totally free methacrylate ormocer composite resin it will be an interesting advance in restorative dentistry. This hypothetic restorative material will own all the advantages of Admira Fusion (VOCO) and avoid all type of allergies related to the presence of methacrylates.

## Conclusion

Admira Fusion (VOCO) composite resin brings innovations to the world of the restorative materials used in dentistry. The total lack of classic methacrylate monomers in this new ormocer composite resin appears as a real advantage in biocompatibility terms. Not only is the leakage reduced but, consequently, the cytotoxicity is too.

Moreover, in *in vitro* studies and clinical trials, it does not demonstrate disadvantages, compared to the materials that already exist in the market. That allows us to think that the absence of BisGMA monomers does not negatively affect the composite resin' characteristics.

This review allows the conclusion that Admira Fusion (VOCO) composite resin is a promising new material, however, more studies are necessary to evaluate other properties, especially in clinical trials.

## References

1. Pfeifer CS. Polymer-Based Direct Filling Materials. *Dental clinics of North America*. 2017;61(4):733-50.
2. Kruly PC, Giannini M, Pascotto RC, Tokubo LM, Suga USG, Marques ACR, et al. Meta-analysis of the clinical behavior of posterior direct resin restorations: Low polymerization shrinkage resin in comparison to methacrylate composite resin. *PloS one*. 2018;13(2):e0191942.
3. Mousavinasab SM, Ghasemi M, Yadollahi M. Evaluation of Enamel and Dentinal Microleakage in Class II Silorane-Based and Methacrylate-Based Resin Composite Restorations Using Specific and Nonspecific Adhesives. *Journal of dentistry (Tehran, Iran)*. 2018;15(4):240-9.
4. Fugolin APP, Pfeifer CS. New Resins for Dental Composites. *Journal of dental research*. 2017;96(5).
5. Pinna R, Usai P, Filigheddu E, Garcia-Godoy F, Milia E. The role of adhesive materials and oral biofilm in the failure of adhesive resin restorations. *American journal of dentistry*. 2017;30(5):285-92.
6. van Dijken JWV, Pallesen U. Durability of a low shrinkage TEGDMA/HEMA-free resin composite system in Class II restorations. A 6-year follow up. *Dental materials : official publication of the Academy of Dental Materials*. 2017;33(8):944-53.
7. Song L, Ye Q, Ge X, Misra A, Tamerler C, Spencer P. New silyl-functionalized BisGMA provides autonomous strengthening without leaching for dental adhesives. *Acta Biomater*. 2019;83:130-9.
8. Rochester JR. Bisphenol A and human health: A review of the literature. *Reprod Toxicol*. 2013;42:132-55.
9. Poureslami HR, Sajadi F, Sharifi M, Farzin Ebrahimi S. Marginal Microleakage of Low-shrinkage Composite Silorane in Primary Teeth: An In Vitro Study. *Journal of dental research, dental clinics, dental prospects*. 2012;6(3):94-7.
10. Rajeev V, Arunachalam R, Nayar S, Arunima PR, Ganapathy S, Vedam V. "Ormocer an innovative technology": A replacement for conventional cements and veneer? A comparative in vitro analysis. *Eur J Dent*. 2017;11(1):58-63.
11. Bacchi A, Pinheiro Feitosa V, da Silva Fonseca ASQ, Assad Cavalcante LM, Silikas N, Jochins Schneider LF. Shrinkage, stress, and modulus of dimethacrylate, ormocer, and silorane composites. *J Conserv Dent*. 2015;18(5):384-8.
12. Indications and Precautions of Admira Fusion available from <https://www.vocodental/en/products/direct-restoration/ormocer/admira-fusion>.
13. O'Neill C, Kreplak L, Rueggeberg FA, Labrie D, Shimokawa CAK, Price RB. Effect of tooth brushing on gloss retention and surface roughness of five bulk-fill resin composites. *J Esthet Restor Dent*. 2018;30(1):59-69.
14. Poggio C, Viola M, Mirando M, Chiesa M, Beltrami R, Colombo M. Microhardness of different esthetic restorative materials: Evaluation and comparison after exposure to acidic drink. *Dent Res J*. 2018;15(3):166-72.

15. Kalra S, Singh A, Gupta M, Chadha V. Ormocer: An aesthetic direct restorative material; An in vitro study comparing the marginal sealing ability of organically modified ceramics and a hybrid composite using an ormocer-based bonding agent and a conventional fifth-generation bonding agent. *Contemporary clinical dentistry*. 2012;3(1):48-53.
16. El-Askary FS, Salah M, Anwar MN, Özcan M. Immediate and delayed repair bond strength of a new ormocer resin restorative material as a function of mechanical and chemical surface conditioning methods. *Journal of Adhesion Science and Technology*. 2017;31(3).
17. Schubert A, Ziegler C, Bernhard A, Burgers R, Miosge N. Cytotoxic effects to mouse and human gingival fibroblasts of a nanohybrid ormocer versus dimethacrylate-based composites. *Clin Oral Investig*. 2018;23(1):133-9.
18. Yang Y, Reichl F-X, Shi J, He X, Hickel R, Högg C. Cytotoxicity and DNA double-strand breaks in human gingival fibroblasts exposed to eluates of dental composites. *Dental materials : official publication of the Academy of Dental Materials*. 2018;34(2):201-8.
19. Beltrami R, Ceci M, De Pani G, Vialba L, Federico R, Poggio C, et al. Effect of different surface finishing/polishing procedures on color stability of esthetic restorative materials: A spectrophotometric evaluation. *Eur J Dent*. 2018;12(1):49-56.
20. Colombo M, Vialba L, Beltrami R, Federico R, Chiesa M, Poggio C. Effect of different finishing/polishing procedures on surface roughness of Ormocer-based and different resin composites. *Dent Res J*. 2018;15(6):404-10.
21. Augusto MG, Borges AB, Pucci CR, Mailart MC, Torres CRG. Effect of whitening toothpastes on wear and roughness of ormocer and methacrylate-based composites. *American journal of dentistry*. 2018;31(6):303-8.
22. Poggio C, Vialba L, Berardengo A, Federico R, Colombo M, Beltrami R, et al. Color Stability of New Esthetic Restorative Materials: A Spectrophotometric Analysis. *J Funct Biomater*. 2017;8(3).
23. Ceci M, Viola M, Rattalino D, Beltrami R, Colombo M, Poggio C. Discoloration of different esthetic restorative materials: A spectrophotometric evaluation. *Eur J Dent*. 2017;11(2):149-56.
24. Llena C, Fernández S, Forner L. Color stability of nanohybrid resin-based composites, ormocers and compomers. *Clin Oral Investig*. 2017;21(4):1071-7.
25. Mailart MC, Rocha RS, Contreras SCM, Torres CRG, Borges AB, Caneppele TMF. Effects of artificial staining on bulk-filled resin composites. *American journal of dentistry*. 2018;31(3):144-8.
26. Yarmohamadi E, Jahromi PR, Akbarzadeh M. Comparison of Cuspal Deflection and Microleakage of Premolar Teeth restored with Three Restorative Materials. *The journal of contemporary dental practice*. 2018;19(6):684-9.
27. McHugh LEJ, Politi I, Al-Fodeh RS, Fleming GJP. Implications of resin-based composite (RBC) restoration on cuspal deflection and microleakage score in molar teeth: Placement protocol and restorative material. *Dental materials : official publication of the Academy of Dental Materials*. 2017;33(9):e329-e35.

28. AIC 19th International Congress and CONSEURO "Clinical Procedures and Digital (r)Evolution: contemporary synergies in conservative/restorative dentistry". Clin Oral Investig. 2017;21(4):1359-433.
29. Politi I, McHugh LEJ, Al-Fodeh RS, Fleming GJP. Modification of the restoration protocol for resin-based composite (RBC) restoratives (conventional and bulk fill) on cuspal movement and microleakage score in molar teeth. Dental materials : official publication of the Academy of Dental Materials. 2018;34(9):1271-7.
30. Mahmoud SH, Al-Wakeel EES. Marginal adaptation of ormocer-, silorane-, and methacrylate-based composite restorative systems bonded to dentin cavities after water storage. Quintessence Int. 2011;42(10):e131-9.
31. Tam CP. Placement Of Complex Direct ORMOCER Posterior Composite Restorations: A Case Report. Cosmetic Dentistry International. 2015;15(4).
32. Gomes de Albuquerque E, Warol Klen Santana F, Signorelli Calazans F, Augusto Poubel L, Soares Marins S, Paris T, et al. A New Universal Simplified Adhesive: 6-Month Randomized multi-center clinical trial. Rev Bras Odontol2017.
33. Hakim F, Vallee J. Use of a Novel ORMOCER as a Universal Direct Restorative Material. Compendium of continuing education in dentistry (Jamesburg, NJ : 1995). 2018;39(1):50-5.

## DECLARAÇÃO

Monografia de Investigação/Relatório de Atividade Clínica

Declaro, que o presente trabalho, no âmbito da Monografia/Relatório de Atividade Clínica, integrado no MIMD, da FMDUP, é da minha autoria e todas as fontes foram devidamente referenciadas.

Porto, 23 de Maio 2019.

A Investigadora:

Marisa Oliveira Furtado

(Marisa Oliveira Furtado)



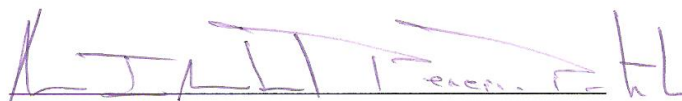
**PARECER**

(Entrega do trabalho final de Monografia)

Informo que o trabalho de Monografia desenvolvido pela estudante Marisa Oliveira Furtado, com o título: "Methacrylate free restorative resins: Admira Fusion", está de acordo com as regras estipuladas na FMDUP, foi por mim conferido e encontra-se em condições de ser apresentado em provas públicas.

Porto, 23 de Maio 2019.

A orientadora:



(Ana Isabel Pereira Portela)