**UNIVERSITY OF MEDICINE AND PHARMACY**
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**FACULTY OF DENTAL MEDICINE**
**1ST DEPARTMENT DENTAL MEDICINE**

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# PhD Thesis

## MODERN CONCEPTS IN DENTAL ADHESION

## SUMMARY

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**CONTENTS**

The choice of this research topic, of considerable importance, was made following the evolution of modern dentistry towards minimally invasive therapeutic methods that use materials that are constantly being improved.

The evolutions of the adhesive techniques and the implications they have in almost all areas of dental medicine have led to a continuous modification of the adhesive materials, constantly increasing their purpose.

In addition to the benefits of the clinical medical branch, the development of adhesive materials has increased the number of studies performed on these types of materials, positively influencing the emergence of new materials belonging to minimally invasive dental medicine.

The research of the adhesive materials represents an important direction within the discipline of Propedeutics and Dental Materials, within the Faculty of Dental Medicine of the UMF "Victor Babeș" Timișoara, direction that has generated different impact studies, as well as carrying out research projects in collaboration with different educational centers from Romania and abroad.

A moment of crossroads in dental medicine is the analysis of the adhesion phenomenon and of the properties of the internal surfaces of the materials used in the adhesive techniques, permanently pursuing the preservation of the hard dental structures.

In restorative dental medicine, the applicability field of adhesive materials is extremely wide, adhesive prosthetic cementations, composite restorations made by direct / indirect techniques, full ceramic prosthetic restorations made by milling / pressing, as well as other applications in endodontics, orthodontics or pedodontics.

The predictibility of adhesive restoration techniques may be influenced by certain factors related to patients such as chewing forces, oral hygiene and bruxism, but also to the fact that some clinicians do not consider the vicious habits of patients, the type of material or the adhesive technique used in the restoration of the concerned area. The choice of adhesive restoration techniques is an extremely important step for the future reconstruction, making an incorrect decision could affect its predictability, but also some parameters that can influence its functionality.

Poor adhesion of composite materials can lead to the appearance of interface defects and micro-infiltrations that favor the appearance of complications in the dental pulp, from a low sensitivity, to the appearance of endodontic pathology. Poor application of the adhesive layer that can generate a thickening of the adhesive can also lead to the marginal percolation of the micro-infiltrations and in time may lead to the appearance of secondary caries.

Some of the major problems of adhesive techniques and materials are the tension and contraction that occurred during the polymerization. The tensions and contractions that may occur during the polymerization process can be counteracted only by a perfect understanding of the phenomena that generate the adhesion process, these tensions and contractions being able to influence the thickness of the adhesive layer, as well as the predictability over time of future restorations. The clinical success of adhesive restorations is determined by several factors, the most important of which is the marginal adaptation. Good marginal adaptation is the key to long-term success of adhesive dental medicine. The presence of marginal percolation can lead to bacterial infiltration with adhesive dissolution and pulp, periodontal complications, as well as prosthetic failures with loss of function and aesthetics.

This thesis has been approached interdisciplinarly from several perspectives including fields such as mechanics, electrochemistry, optics and medical imaging, statistics, nanotechnology and chemistry.

The novelty of this type of adhesive requires preliminary studies to determine the properties and to evaluate the behaviour of the nanoparticles within the adhesive mass, in order to minimize the thickness of the adhesive layer applied on the dental surfaces in order to develop new working protocols applied in minimally invasive dental medicine.

The thesis is divided into two main parts : 1. General part - with 2 chapters, 2. Specific part - with 4 chapters and 3. Conclusions and personal contributions. The general part of the thesis will describe the generalities of adhesion phenomena and surface properties, as well as the classification of adhesive systems and their applications in dental medicine.

For these reasons, the choice of the theme is based on specific research directions that can complement or bring clarifications to previous studies, contributing to the improvement of adhesive techniques, resulting in much more durable restorations.

An innovative aspect of this thesis is the addition of ferric nanoparticles in the adhesive techniques and the use of magnetic fields to include them in the dental adhesive, resulting in the definition of a new type of adhesive that by the thickness generated after application on the dental surfaces will minimize the risks of occurring microinfiltration.

The main scientific objectives of this research are:

1. The imaging evaluation carried out by means of micro computer tomography of the adhesive interfaces loaded with ferric nanoparticles applied on the hard dental surfaces of the cavities that have been filled with composite materials, as well as the analysis of the three-dimensional image reconstructions of the interfaces of interest;

2. Imaging evaluation using optical microscopy and micro-computer tomography of adhesive interfaces loaded with ferric nanoparticles applied to the hard dental surfaces of the teeth and cavities in magnetic field applied to the surfaces of the teeth at different time intervals;

3. Imaging evaluation of adhesive interfaces loaded with magnetic nanoparticles and applied on the occlusal surfaces of the teeth in the sealing procedures of grooves and pits using resin materials;

4. Imaging evaluation using optical microscopy and electron microscopy of adhesive interfaces loaded with encapsulated ferric nanoparticles for a better aesthetic effect applied on the hard dental surfaces of teeth and cavities in magnetic field applied to the surfaces of teeth at different time intervals;

5. Qualitative and quantitative analysis of the adhesive interfaces loaded with nanoparticles and applied on the surfaces of the teeth in magnetic field by means of X-ray spectrofluorometry;

The specific part is divided into four chapters, each approaching the problem described from a different perspective:

1. MicroCT analysis of dental adhesives loaded with ferric nanoparticles;

2. Imaging analysis of dental adhesives loaded with magnetic nanoparticles, applied in a magnetic field on the surface of the teeth, in the grooves and pits sealing operations;

3. Influence of encapsulated polymeric nanoparticles on the adhesive layer used in composite restoration of class I cavities by Black

4. Imaging evaluation of dental adhesives loaded with magnetic nanoparticles and applied on dental surfaces in magnetic field.

Analysis of shear strength of adhesive interfaces loaded with magnetic nanoparticles and applied on dental surfaces in magnetic field at different time intervals.

**In the first chapter** of the specific part (the third of the total), entitled "MicroCT analysis of dental adhesives loaded with ferric nanoparticles", is presented a study that aimed at the image evaluation using micro computer tomography, the existing adhesive interfaces in the restoration with composite materials of class I and class II cavities. In the study, for half of the samples, a dental adhesive was used loaded with ferric nanoparticles, which leads to the uniformity of the thickness of the adhesive layer.

**In the second chapter** of the specific part (4th of the total), entitled "Imaging analysis of the dental adhesives loaded with nanoparticles, applied in a magnetic field on the surface of the teeth, in the sealing workings of grooves and pits" were evaluated, with the help of optical

microscopy and coherent optical tomography, the adhesive interfaces resulting from the magnetic field application on the hard dental surfaces of the composite resins of the grooves, pits and cracks of an adhesive loaded with ferric nanoparticles, making comparative measurements with the conventional sealing techniques. The results show the decrease of the thickness of the adhesive layer, as well as its uniformity on the surface.

**In the third chapter** of the specific part (5th of the total), entitled "The influence of the encapsulated polymeric nanoparticles on the adhesive layer used in the composite restoration of the class I cavities by Black" it was evaluated by the help of microscopy, electronic scanning and with the help of digital optical microscopy, the adhesive interfaces resulting from the application in magnetic field on the hard dental surfaces in the procedures of restoration with composite materials, of an adhesive loaded with ferric nanoparticles encapsulated in a zinc oxide membrane, making qualitative comparative measurements depending on the activity of the magnetic field. The results show the decrease of the thickness of the adhesive layer, as well as its uniformity on the surface.

**In the last chapter** of the specific part (6th of the total), entitled "Image evaluation of dental adhesives loaded with magnetic nanoparticles and applied on dental surfaces in magnetic field", was evaluated the integrity of the adhesive layer applied on the dental surfaces in magnetic field for 5 and 10 minutes. The adhesive interfaces were imaging analized using micro computer tomography, digital optical microscopy, scanning electron microscopy ending with mechanical testing.

The statistical analysis performed on the samples indicated that, with the increase of the application time of the magnet on the hard dental surfaces at 10 minutes, the thickness of the adhesive film is minimal and the distribution on the surface being uniform. The loading of dental adhesives with ferric nanoparticles and their application on the dental surfaces in magnetic field leads to the thinning and uniformity of the adhesive film between the composite restorative materials and teeth.

The general conclusions of thel PhD thesis, presented extensively in the last chapter - "Own conclusions and contributions" were:

- demonstration that the method of loading the adhesives and their application on the dental surfaces using a magnetic field is easy and accessible

- the use of adhesives charged with magnetic nanoparticles and their application in active magnetic field, can be extended to all adhesive restorative works

- the use of an active magnetic field in the technique of applying the adhesive on the dental surfaces can reduce the thickness of the adhesive film

- the increase of the time of application of the magnetic field can lead to the decrease of the thickness of the adhesive layer, but also to its uniformity in the surface

- the use of microcomputer tomography is the optimum technique to analyse "in-vitro", in the case of dental adhesives, by scanning and performing three-dimensial imaging reconstruction, that allows their analysis on all types of surface.