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"VICTOR BABEȘ" UNIVERSITY OF MEDICINE AND PHARMACY FROM TIMISOARA

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PHD THESIS

MODERN APPROACHES IN THE IMPRESSION TECHNIQUES

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Dental impression techniques play a crucial role in the field of prosthodontics, significantly impacting the success of restorative dental treatments. The precision and accuracy of these techniques are necessary, as they determine the fit and functionality of dental prostheses. Traditional impression methods, such as those utilizing alginate and elastomeric materials, have been the standard for many years. These materials, including polyvinyl siloxanes (PVS), polyethers, and condensation silicones, have been refined to improve their accuracy and ease of use.

Alginate, a commonly used hydrocolloid, is favoured for its simplicity and cost-effectiveness, but it lacks the dimensional stability required for highly precise work. Elastomeric materials, particularly polyvinylsiloxane, offer better accuracy and stability, making them suitable for more detailed prosthetic work. However, even with advancements in these materials, conventional impression techniques are still prone to errors due to factors like improper gingival retraction, material handling issues, and dimensional changes during setting and storage. Improvements in the impression materials and techniques make the possibility of obtaining an ideal impression even closer.

In recent years, digital impression techniques have emerged as a revolutionary alternative to conventional methods. Intraoral scanners (IOS) have transformed the way dental impressions are captured, offering numerous advantages in terms of accuracy, efficiency, and patient comfort. Digital impressions eliminate many of the issues associated with traditional methods, such as the need for physical impression materials and the potential for dimensional changes.

The accuracy of digital impressions is often superior to that of conventional techniques. Studies have shown that intraoral scanners can capture detailed 3D images of the dental arches, allowing for precise measurements and better fitting prostheses. The ability to instantly evaluate and adjust digital impressions further enhances their accuracy. Additionally, digital files can be easily stored, shared, and integrated with computer-aided design and manufacturing (CAD/CAM) systems, streamlining the workflow and reducing the turnaround time for dental restorations.

Despite the clear advantages, digital impression techniques also face challenges, particularly in capturing subgingival details and managing moist environments. However, ongoing advancements in scanner technology and software continue to improve their accuracy and usability.

The shift towards digital impression techniques represents a significant advancement in dental prosthodontics. By enhancing the precision and reproducibility of dental impressions, these modern approaches contribute to better patient outcomes and more efficient clinical workflows. The integration of digital technologies in dental practices is poised to redefine the standards of accuracy and reliability in restorative dentistry.

This PhD thesis, titled "Modern approaches in the impression techniques," is a comprehensive study structured to explore and evaluate various dental impression techniques, both conventional and modern. The thesis is organized into two major parts: the General Part and the Special Part, each consisting of multiple chapters that systematically address different aspects of the research topic.

The general part comprises three chapters that analyse the relevant literature. These chapters are essential for understanding the significance of the studies conducted in the specialized section.

The first study of this PhD thesis was a review and represents the starting point from which **Chapter 1** of this doctoral thesis was developed. It introduces conventional and digital dental impressions, detailing the types of materials used (e.g., alginate, elastomeric impression materials), their properties, and their clinical applications. It also covers the operating modes of intraoral scanning systems and the factors influencing their accuracy.

Chapter 2 discusses various methods of gingival retraction necessary for accurate dental impressions. It includes mechanical, chemical, chemo-mechanical, and surgical methods, explaining their procedures, benefits, and potential complications.

In **Chapter 3,** the use of ultrasound in dentistry is explored, explaining its operating principles, advantages, and disadvantages. It also covers the different modes of ultrasonography (e.g., Mode A, Mode M, Mode B, Mode D) and their specific applications in dental diagnostics and treatment.

The special part includes four studies and a chapter dedicated to describing a patent, invented as part of the analysis of current impression techniques in this doctoral thesis.

The second study of the PhD thesis, (the first of the special part), described in **chapter 4**, focuses on the experimental comparison of time efficiency between conventional and digital impression techniques. It includes a detailed methodology for the experimental model preparation, gingival retraction, and the time assessment of impression procedures.

The study aimed to conduct an ex-vivo time analysis to compare conventional and digital impression methods for prosthodontic restorations. The insights obtained from these experiments promise to enhance current practices. This primary experimental investigation focused on both clinician and patient needs when determining the most appropriate treatment modalities.

The study was divided into five stages: It began with the preparation of an artificial arch, where a Frasaco maxillary model featuring 16 teeth was employed. Out of these, 14 teeth were meticulously prepared using cylindrical-conical burs to create the necessary conditions for the study.

Following the preparation, the focus shifted to measuring the time required for gingival retraction. This involved a detailed evaluation of both traditional retraction cords and the more contemporary retraction paste, with each method's duration meticulously recorded.

Next was the critical time assessment of the impressions. Both conventional and digital impression techniques were scrutinized, with precise measurements taken to capture the time required for each method. This phase was essential to establish a clear comparison between the traditional and modern approaches.

With the data in hand, the final stage involved a thorough analysis. The recorded times were carefully examined to compare the efficiency of the conventional and digital methods. This comprehensive data analysis aimed to reveal the strengths and weaknesses of each technique, providing valuable insights into their relative efficiencies and potential applications in dental practice.

The time analysis revealed varying durations for the gingival retraction techniques. The retraction paste method was significantly faster than the retraction cords. Digital impressions showed shorter scanning times compared to conventional methods, particularly for a smaller number of teeth. While conventional two-step impressions took longer, they provided better fidelity in the cervical area.

The study underscored the efficiency of digital scanning, which offered shorter impression times and reduced patient discomfort. It also highlighted the differences between retraction methods, noting their varied impacts on periodontal tissues and impression quality. Comparative studies pointed out the benefits and challenges associated with each impression technique.

Although the study did not delve into the effects on gingival tissue, it highlighted crucial considerations for impression materials and chemical solutions. These insights provide valuable guidance for practitioners in choosing the most effective techniques for efficient and accurate dental procedures.

The **third study** (the second of the special part) was described in **chapter 5** and analysed the advantages of the implementation of digital impressions over conventional methods. This chapter includes material and methods for conventional and digital impression procedures, digital model printing, and intraoral scanning, along with their results and discussions.

The aim of this study was to compare conventional impression techniques with intraoral and extraoral scanning methods, as well as plaster models with virtual and 3D printed models, focusing on working time and fidelity.

The study involved two groups of practitioners: 30 dentists and 30 dental technicians, assessing their ability to register and reproduce the prosthetic field. The time required for each operation was evaluated, considering variables that could influence the final results. Conventional impressions were performed using both monophasic and biphasic techniques. In the digital workflow, an intraoral scanner (Medit i700) and a laboratory scanner (Medit T310) were used, along with a 3D printing machine (Elegoo Saturn) to print the models.

The average time for conventional impressions ranged from 8 minutes and 20 seconds to 25 minutes and 40 seconds. Scanning times for digital impressions varied between 5 minutes and 30 seconds and 12 minutes and 40 seconds.

The study concluded that digital impressions require less working time compared to conventional methods. However, conventional impressions cannot be entirely replaced, especially for mobile prostheses. The fidelity of prosthodontic field reproduction significantly influences the adaptation of restorations.

Chapter 6 provides a comprehensive guide on using a new dental impression technique, detailing the materials and methods involved in the creation and use of the dental impression guide, as described by **the patent**.

The invention pertains to a dental impression device designed for creating fixed prosthetic restorations and a method of using it. The device, as described in the invention, consists of a body shaped like a cover for the prepared teeth of a patient. This body contains one or more cavities, corresponding to the number and shape of the prepared dental abutments, on which the fixed prosthetic work is built. Externally, the covering segments have a conical shape and are connected by continuity bridges. These bridges ensure conformity with the configuration of the dental arch being restored and provide a height of the body of the guide, which is adapted to the average height of the abutments.

The method of using the invention involves more stages. First, the impression device is preliminarily positioned on the abutments. A conventional impression is taken with the body of the device incorporated into the high viscosity impression material. Fluid silicone is injected into the impression device with the body incorporated into the previously taken high viscosity impression. The final impression is taken and used to obtain a fixed prosthetic restoration.

This chapter highlights the utility of this new impression technique, with the potential of improving the dimensional stability of the final impression. Also, by its positioning on the abutments, it presses on the gingiva, and excludes the need of gingival retraction cords.

The **fourth study** (the third of the special part) was described in **chapter 7**. A comparative study between traditional dental impressions and those reinforced with rigid mouthguards is presented, including sample preparation, measurement protocols, statistical analysis, results, and discussions.

Current dental impression materials offer good reproducibility and are well accepted by patients. However, their polymer-based nature leads to issues with dimensional stability.

To address this, the present study proposes a new type of dental impression, reinforced with rigid mouthguards.

The study aims to test the performance of these new reinforced impressions compared to conventional ones, focusing on dimensional stability.

Three types of polymeric materials were evaluated for both conventional and reinforced impressions: alginate, condensation silicone, and addition silicone. The process for creating the new type of impressions involved several key phases. Initial impressions were taken using standard techniques. A plaster model was duplicated, and 15 rigid mouthguards were produced. Each mouthguard was positioned on the cast before the high-consistency material was placed in the tray, and the impression was made. The mouthguard remained in the tray, and low-viscosity material was inserted over it. The impression was positioned on the model, and after the material hardened, the mouthguard-reinforced impression was analyzed.

The study's evaluation of dimensional stability involved rigorous statistical analysis using non-parametric Mann–Whitney U tests due to the non-normal distribution of the data. The results indicated a statistically significant improvement in the dimensional stability of addition silicone impressions when reinforced with mouthguards ($p < 0.05$), demonstrating superior performance over conventional methods. However, reinforced impressions made with alginate and condensation silicone did not show the same level of stability improvement, indicating the need for further optimization of these materials.

The chapter concluded that among the three elastomers considered, addition silicone emerged as the prime candidate for high-precision dental impressions. The proposed reinforcing technique significantly improved the quality of addition silicone impressions compared to conventional methods, highlighting its potential for use in dental practices. Further research is needed to optimize the reinforcement of alginate and condensation silicone impressions.

The **fifth study** (fourth of the special part) is currently in the process of being published and is presented in **chapter 8**. This is an in vitro study comparing ultrasonographic and optical impressions. It includes the description of materials and methods, results, discussions, and conclusions.

This study aims to analyze and compare the precision and benefits of three impression techniques: a prototype ultrasonographic system, an intraoral optical scanner, and a laboratory 3D scanner. The key questions addressed are whether the ultrasonographic impression technique achieves acceptable precision compared to optical systems and if there are any benefits to using this method.

For this study, a pig mandible was sectioned into three parts: two lateral segments containing the molars and a frontal segment containing the incisors. The frontal segment was excluded due to not meeting the study requirements. Each of the two lateral segments contained six teeth prepared with a subgingival chamfer finish line.

The following scanning methods were employed: a laboratory scanner (DOF – Freedom HD Dental Scanner), a chairside dental scanner (Planmeca PlanScan (Romexis v4.6.2, powered by E4D Technologies, LLC, Richardson, TX, USA, 2014)) and a prototype ultrasonographic system (Vinno 6 and RPS EVO 7 articulated measurement arm).

3D reconstructions from these methods were compared using an open-source software (Cloud Compare v2.6.3).

The study observed that optical impression techniques, while precise and producing high-quality 3D reconstructions require the use of retraction cords. The ultrasonographic impression technique demonstrated significant benefits: it could penetrate gingiva and any liquid on the tooth surface, allowing for accurate scanning of the finish line, without the need of retraction cords.

The ultrasonographic impression technique has the potential to complement or even replace optical impressions in certain scenarios, particularly where hard tissue is covered by gingiva. This technique can be particularly useful for estimating the biological space, ensuring that prosthetic restorations do not invade this area. The study suggests that ultrasonographic impressions could provide an effective alternative to optical systems, especially in cases where soft tissue coverage complicates accurate scanning.

The final **CONCLUSIONS** provide a comprehensive summary of the findings and implications of the research on dental impression techniques.

The chapter concludes that while significant progress has been made in dental impression technologies, ongoing research and technological development are crucial for advancing the field and ensuring these innovations can be effectively integrated into clinical practice.