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VIRTUAL ARTICULATORS AND INTEROCCLUSAL RECORDS IN FIXED PROSTHODONTICS - LITERATURE REVIEW

ВИРТУЕЛНИ АРТИКУЛАТОРИ И ИНТЕРОКЛУЗАЛЕНИ ЗАПИСИ ВО ФИСКНА ПРОТЕТИКА - ПРЕГЛЕД НА ЛИТРЕРАТУРА

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Abstract

Over the years, mechanical articulators have been widely used to design and fix prosthodontics. The mechanical articulators have had some challenges which have prompted dentists to use virtual articulators. Notably, virtual articulators utilize virtual application programs to capture occlusal movements for interocclusal records and fixed prosthodontics. The mechanical articulators have had their fair share of challenges in that it has been a challenge to capture occlusal movements while the design of the machines changed often. The materials, commonly used in mechanical articulators to register occlusal details, have often decomposed hence posing trouble for patients regarding the quality of bite. Therefore, the registration materials used to capture occlusal materials are critical in ensuring that dentists fit prosthodontics perfectly. The literature review analyzes secondary data on virtual articulators' various features. Also, the research paper focuses on the challenges dentists face when using occlusal registration materials and mechanical articulators. The study further looks at the solutions brought forth by the virtual articulators regarding registering occlusal records. **Key words:** Virtual articulators, prosthodontics, mechanical articulators, interocclusal records, and virtual reality.

Апстракт

Долги години, механичките артикулатори се широко користени за дизајнирање и фиксирање во протетиката. Механичките артикулатори имаа некои предизвици коишто ги натераа стоматолозите да користат виртуелни артикулатори. Виртуелните артикулатори користат програми за виртуелна апликација со цел да ги забележат оклузалните движења за интеркоклузални записи во протетиката. Механичките артикулатори имаа големо учество во предизвиците да се регистрираат оклузалните забележувања и покрај честото менување на дизајнот. Материјалите што најчесто се користат кај механичките артикулатори за детали на оклузалното регистрирање, со тек на време претрпуваат промени, што претставува проблем во однос на квалитетот на загризот. Затоа, материјалите за регистрација на оклузијата се од клучно значење за да се осигура дека стоматолозите совршено ги изработуваат протетичките изработки. Прегледот на литературата ги анализира секундарните податоци за различните карактеристики на виртуелните артикулатори. Исто така, трудот се фокусира на предизвиците со кои се соочуваат стоматолозите кога се користат оклузални регистрациони материјали и механички артикулатори. Студијата понатаму ги разгледува решенијата донесени од виртуелните артикулатори во врска со регистрирање на оклузалните забележувања. **Клучни зборови:** Виртуелни артикулатори, протетика, механички артикулатори, интеркоклузални записи и виртуелна реалност.

Introduction

There have been technological transformations in the 21st century, such as the introduction of virtual articulators in fixed prosthodontics[1]. The medicine field, to be specific, the branch of dentistry, has introduced virtual articulators to improve hygiene and dental health in fixed prosthodontics[2,3]. Notably, mechanical articulators have been widely used to register interocclusal and design prosthodontics used to fix artificial teeth[4]. However, mechanical articulators have had many challenges emanating from capturing accurate details and interocclusal records, which are critical in designing and manufacturing artificial mouth components[5,6].

The adoption and application of virtual articulators has been slow but steady. In the west, specifically in the US, dentists and clinics are adopting virtual reality in fixed prosthodontics[7,8]. DentCam technology is the most common type of virtual articulators widely used in the west due to their efficiency and cost of operating virtual reality in designing and fixing prosthodontics[9]. On the contrary, developing countries in Africa are slow in applying virtual articulators due to the lack of trained human resources[11]. Additionally, most hospitals in rural

areas lack electricity which is essential in powering computing devices and components of virtual reality[12, 13].

Objective

There are several aims that the literature review strives to meet. Firstly, the paper aims to discuss the various problems and challenges associated with mechanical articulators. Secondly, the research focuses on the difficulties related to the use of interocclusal data records registered by mechanical articulators. Thirdly, the paper outlines some of the robust solutions that virtual articulators are associating with the use of mechanical articulators. Some of the solutions include: registering accurate occlusal impressions, designing, and manufacturing prosthodontics that are custom made. Fourthly, the review gives the benefits of using virtual articulators as an effective technological tool in fixed prosthodontics.

Material and methods

The research paper utilizes numerous journal articles and books to build the hypotheses of the paper. The journal articles are peer-reviewed by teams of scholars who have robust knowledge in medicine and, by extension, dentistry[14,15]. The paper leverages several books online to discuss the importance of virtual articulators in registering static and dynamic occlusal records[16,17]. The paper synthesizes journal articles and books to give detailed research on the effectiveness and parts of virtual articulators in registering occlusal records in designing and fixing prosthodontics[18,19]. The criteria used are that the journal articles and books should be scientific, containing primary and secondary data[21,22]. Secondly, the study done by a research material should be around virtual articulators, prosthodontics, interocclusal records, dentistry, and dynamic occlusion based on the human population.

Thirdly, the materials are supposed to be in English since the primary language of research is English. Fourthly, the research contained in the material should be authentic and based on science[23,24]. Fifthly, the material should have been written and published within the last decade, that is, from 2011 to 2021 to ensure that the data is updated and features technological advances such as virtual reality. The sixth criteria is that the material should be well written, organized[25,26] coherent and interesting in addressing the issues of virtual articulators, interocclusal records, and artificial teeth.

Discussion

Over the years, there have been widespread complaints from dentists related to wear and tear nature of mechanical articulators. Studies have shown that the prolonged use of mechanical articulators interferes with registering interocclusal records[27]. Some of the mechanical articulators rust, making it difficult to get the exact size of occlusal in the maxilla and mandibular[28,29]. In addition, an overused mechanical articulator is prone to plastering excess cast on the occlusal[30]. The failure of mechanical articulators to plaster the correct amount of cast on the maxilla and mandibula further the bite problem of a patient by interfering with the interocclusal records.

The use of mechanical articulators has, on numerous occasions, reduced the effectiveness of fixed prosthodontics. As a result of decomposing materials that generate interocclusal data, there is the problem of casting on occlusal impressions that form the outer part of prosthodontics[31]. Consequently, the cast impression leaves spaces in the prosthodontics, which creates extra dental problems. The spaces left by mechanical articulators affect the quality of the bite. A patient may not be able to chew food effectively, especially if it is made up of hard contents[32]. Also, the use of mechanical articulators contributes to manufacture of prosthodontics with a poor orientation that may lower a person's self-esteem. Besides, mechanical articulators use excessive plasters that are detrimental to an artificial tooth's stability due to the excess weight on the mandibular and maxilla. Subsequently, the numerous challenges associated with mechanical articulators create the need to have an effective, durable, and accurate device for recording details of mouth components[33].

A virtual articulator uses software designed to improve interocclusal records and prosthodontics' outcome and effectiveness[34]. Virtual articulators are banked on virtual reality that entails using a computer-generated simulation program that allows a dentist to interact with 3D objects registered by using specially made face bow devices. In other words, a dentist is literally placed in another world where they interact with 3D images simulated in computers[35]. Virtual articulators give a dentist a room to explore different possibilities of designing, manufacturing, and fixing prosthodontics before commencing the clinical work. Besides, virtual articulators play an integral role in verifying the interocclusal records registered before setting prosthodontics to determine the artificial tooth's effectiveness.

Furthermore, virtual articulators have revolutionized the practice of restorative dentistry[36]. Unlike mechanical articulators that are time-consuming and difficult to clone and customize prosthodontics, virtual articulators have made it possible for dentists to customize prosthodontics according to the patient's specification obtained from a virtual articulator's registry[37]. Prosthodontics' customizations is a growing technology that has continued to put smiles on millions of people. It is important to note that the use and application of virtual articulators has faced

several challenges. One of the difficulties has entailed the training of dentists. Most dentists trained in the 20th century lack the necessary skills to generate computer-simulated 3D images from virtual articulators[38]. The number of dentists that have gone back to the university to study the use of virtual reality in restorative dentistry is minimal, depending on the number of people that require prosthodontics.

The other challenge of virtual articulators relates to virtual reality technology's initial and maintenance costs. As compared to mechanical articulators, virtual articulators are slightly expensive as they require installing information systems such as computers, the internet, and storage to aid the simulation of objects[39]. Virtual articulator technology requires continuous updates and verification to prevent unauthorized personnel from accessing the software. Maintaining virtual technology is expensive since it requires professionals, both trained and experts, in dentistry and information technology. The price of peripheral devices such as digital face bow is costly for hospitals and dentists to buy, and requires a budgetary allocation to facilitate the procurement of complementary technology like software.

Despite some of the challenges associated with virtual articulators, the advantages outweigh the shortcomings. Virtual articulators can give real-time data critical in improving the accuracy of interocclusal data[40]. The data generated from mechanical articulators takes a certain amount of time to register data, increasing the amount of time required to design and manufacture fixed prosthodontics. It is imperative to underscore that as virtual articulators transmit real-time data, the dental arches' images captured are not clear. However, the jaw movements are captured and used to determine a prosthodontics' dental arching.

Nevertheless, virtual articulators improve the quality of dentures produced through enhanced communication. The virtual reality used in fixing artificial teeth provides a fundamental platform where both the dentist and the dental technician can access data on interocclusal seamlessly. The use of virtual articulators enables dentists to send 3D simulations of interocclusal movements to dental technicians efficiently[42]. The technology has an option of sharing data and information from one party to another, which enhances the practice of sharing data with different people. Besides, the patient can also be enlightened on how virtual articulators are capable of improving their prosthodontics by showing them a simulation of jaw movements on the screen.

The new applications in dentistry have been instrumental in bolstering good dental health and efficient restorations. However, there have been minimal journal articles, books, and publishing that have provided credible and updated data on the application of virtual articulators and interocclusal records in fixed prosthodontics[42]. One of the fundamental contributions relates to the features of virtual articulators. Different types of virtual articulators are applied in the world depending on the country, cost, and technology used in developing the articulators. In western countries such as the United States of America and the UK, DentCam virtual articulators have been widely used as the standard virtual reality technology[43] The adoption of DentCam as the standard virtual articulator has been informed by the fact that DentCam offers real-time data on simulation movement of jaws and occlusal. DentCam virtual articulators have four essential features that register interocclusal records in fixing artificial teeth[44]. Virtual articulators' features are the rendering window, slice window, smaller window, and occlusion window.

The rendering window registers interocclusal records of the mandibular and maxilla from angles that capture the cusps of the occlusal. Additionally, the rendering widow plays an integral role in showing how antagonistic movements of teeth occur[45]. The second feature of DentCam is the slice window that shows the dental arch's frontal part, which makes it easy to balance jaw movements. Thirdly, the occlusion windows illustrate the mandibular and maxilla jaws' occlusion that show the statistic and dynamic occlusion. The fourth feature is the smaller window that shows temporomandibular movements' features with respect to occlusal, which gives a transversal angle.

Nonetheless, virtual articulators require well-detailed images of 3D representation of jaws. The 3D images are registered using virtual reality technology[46]. The data about the patient's jaw movement are required to ascertain occlusal movements. It is imperative to underscore that jaw and occlusal movements differ from one person to another depending on the dental formula and the quality of the bite. After presenting 3D images and jaw movements, virtual articulators simulate the jaw movements to show a dentist how a visual image of occlusion is going to come into contact[47]. The simulation may be presented in terms of a video or an image, depending on the type of data the dentist requires.

Patients have different occlusal and jaw movements. When designing and manufacturing prosthodontics, there is some force applied on a mechanical articulator to adjust the interocclusal records of a patient. The process of adjusting the mechanical articulator to produce the prosthodontics' desired design affects the setting of the articulator by reducing the accuracy of customizing the right size of occlusal and jaw movements[48].

Unlike mechanical articulators, virtual articulators enable a dentist to edit interocclusal records by kinematic analysis to ensure that the design of artificial teeth match-

es the records and settings of a patient[49]. The virtual articulator tool allows an individual to virtually adjust the positions of occlusal simulations. On the other hand, a dentist has to adjust the settings of a mechanical articulator, which increases the chances of wear and tear. When it comes to casting, a dentist is forced to manually fix the cast on a prosthetic which may take a long time when performing a full mouth restoration. However, virtual articulators enable dentists to virtually fix cast and perform a mouth rehabilitation by applying the CAD systems[50].

Research patterns and principles

The research on virtual articulators and mechanical articulators follows certain principles and patterns to ensure that the conducted research meets the required threshold. The hypothesis behind the study is that virtual articulators are considered to be more effective than mechanical articulators, especially when it comes to registering static and dynamic occlusion data. The study is structured in a manner that either confirms or disapproves the hypotheses of the research. Subsequently, the research paper synthesizes primary and secondary data to help in identifying how virtual articulators help in the process of designing, manufacturing, and fixing prosthodontics. The clinical measurements of both dynamic and static occlusion are factored in to inform the researchers on how different occlusion generates different data in terms of interocclusal records[51].

The research applies the principle of using quantitative data to generate and analyze statistics that relate to the use of virtual articulators and mechanical articulators. There are numerous secondary sources of data that contain data on the dynamic and static occlusion records with regard to articulators. The data provided by other scientific journals form a fundamental base of analysis with the data generated from the research[52]. In other words, secondary data plays a huge role in asserting or disapproving that virtual articulators are more effective than mechanical articulators.

Furthermore, the research leverages on secondary data to look at the trends associated with the use of virtual articulators. The research data collated shows that as much as there is still use of mechanical articulators, virtual articulators are slowly gaining traction among dentists.

The increasing trend in the use of virtual articulators is bolstering the provision and fixing of high-quality and customized prosthodontics. In countries such as the United States of America and the United Kingdom, the number of people seeking prosthodontics is constantly increasing[53]. The increase in the number of people seeking prosthodontics services is a clear indication that patients have a positive attitude and trust towards the use of virtual articulators in improving interocclusal records registers, and fixing artificial teeth.

Suggestions for further research

The future of dentistry is greatly hinged on virtual articulators. However, there is a need to perform further research on the future and effectiveness of virtual articulators over mechanical articulators[54]. One of the suggestions for future research is to find out the level of training of dentists with regard to the use of virtual articulators. The current studies show that the number of dentists that have the knowledge to operate and use virtual articulators is still minimal. Further research should be conducted to examine the strides made in training dentists on the use of technology such as virtual reality, robotics, and artificial intelligence.

Likewise, future research should be conducted on the standardization of virtual articulators. The use of technology is revolutionizing dentistry, but there is a need to standardize the use of virtual articulators[55]. Future research should be conducted to ascertain what dentistry boards and agencies are doing to ensure that the virtual articulators that come to the same market have a certain level of efficacy. The study on standardization will give dentists an overview of the virtual articulators in the market and how effective they are. Currently, DentCam is the standard articulator that is used widely[56]. More research is necessary to analyze the effectiveness of other virtual articulators with regard to simulating interocclusal data in generating 3D images and occlusal movements[57].

Comparatively, more research should be done on how to improve the effectiveness of virtual articulators. Research should be conducted to examine how virtual articulators can handle more prosthodontics[58]. The points of focus should be on how to simulate more than one interocclusal movement and 3D images by using virtual reality technology[59]. In addition, the privacy of the patient's data is an aspect that should be extensively researched. Data privacy is a major issue in most countries. More studies should be done on how to secure the data handled by virtual articulators to ensure that no unauthorized person has access to the data[60].

Conclusion

For quite a long time prosthodontics has been defined by the use of mechanical articulators which have posed numerous problems. Mechanical articulators have had challenges such as destroying occlusal materials that are used in registering dentures. However, virtual articulators are defining dentistry by offering solutions to challenges posed by mechanical articulators, and improving

the design and manufacturing of fixed prosthodontics. Virtual articulators are improving the quality of life of people by improving their mouth components with definite fixed prosthodontics. The use of virtual articulators improves the effectiveness of registering interocclusal records by enabling dentists to capture different angles of occlusion in the mandibula and maxilla. Nevertheless, there is a need to conduct more research to improve the number of interocclusal records that virtual articulators can register simultaneously.

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