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Editorial

Current Orientations of Surgical–Prosthetic Rehabilitation: Analogue, Digital and Biomechanical Considerations

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In the last decade, the available digital technologies have made it possible to expand the range of therapeutic options, simplify operational protocols and improve therapeutic plans due to a greater focus on diagnosis and operational protocols.

Much progress has been made in the field of bioengineering and biotechnology, which has resulted in a diverse knowledgebase through literature studies, thus rendering treatment less invasive for patients and enabling us to evaluate and determine the best therapeutic choices through data processing alone. A Federal Drug Administration (FDA) document released in September 2016 states that "computational modelling and simulation studies, along with over-the-counter, non-clinical in vivo, and clinical studies, can be used to evaluate the safety and efficacy of medical devices" that hitherto remain little-known due to failures or problems that occur as a result of early loads and, frequently, prosthetic inconsistencies that arise during prosthetic rehabilitations. Prostheses have evolved over time to meet the growing needs of patients, and advancements in this technology have enabled the development of more sophisticated devices. With the introduction of digital technology, the traditional analogue methods have been augmented, leading to a shift in focus from mechanical to biomechanical considerations [1].

Analogue prosthetic rehabilitation involves the use of non-digital devices, which can be either static or dynamic. Static prostheses are used to provide support and stability to body parts, while dynamic prostheses mimic the movements of natural body parts. Analogue prostheses are made of materials such as plastic, metal, or carbon fiber and are attached to the body with straps or sockets. The main advantage of analogue prostheses is their simplicity, durability, and low cost. However, they lack the sophistication and versatility of digital prostheses. Digital prosthetic rehabilitation involves the use of computer-aided design and manufacturing (CAD/CAM) technology to create highly customized prostheses. Digital prostheses are made of lightweight and durable materials, such as titanium, and can be osseointegrated. Digital prostheses offer several advantages over analogue prostheses, including greater precision and reduced discomfort; however, they are more expensive. Biomechanical considerations play a crucial role in the design and use of prostheses. Biomechanical considerations in prosthetic rehabilitation include the design of the prosthesis and its materials. The design of a prosthesis must take into account the biomechanics of the body part being replaced, as well as the activities and environments in which the prosthesis will be used. Materials used in the prosthesis must be durable, lightweight, and biocompatible. Digital implant–prosthetic rehabilitation has emerged as a promising field of study, which utilizes computer-aided design and manufacturing (CAD/CAM) technology to create customized implant–prosthetic devices. This approach provides a high level of accuracy, efficiency, and predictability, which can lead to improved patient outcomes. Digital implant–prosthetic rehabilitation involves a combination of digital scanning, implant planning, virtual surgery, and the fabrication of the prosthetic device. The use of digital technology enables the creation of more precise and aesthetically pleasing prosthetic devices while reducing the risks of implant failure and complications [1]. In addition to the many factors that can influence our therapeutic choices, such as age and

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gender, it is also important to examine the tone of the masticatory muscles. Furthermore, a careful intraoral evaluation of the patient is necessary, together with a check for the presence of teeth in the arch to be rehabilitated, a careful evaluation of the proprioceptive conditions, and a check for the possible presence of healthy dental elements distal to the treatment plan. All of these elements provide the nervous system with different types of information related to chewing. A clinical situation in which a patient needs to be fully rehabilitated with implants is much more complex than a clinical situation in which the dental elements of a single hemiarch need to be replaced, which is even simpler in cases requiring the replacement of a single dental element. In the decision tree, the condition of the opposing arch plays an important role, since it is opposed to the prosthesis that will be created. The periodontal situation, the number of teeth, and the morphological aspects can reveal previous para-functions or chewing overloads. All of this is taken into account with a view to possible future changes, such as the transition from a total prosthesis to an implant-supported fixed prosthesis [2].

The teeth to be replaced in implant–prosthetic rehabilitation perform different functions, and their simple observation obliges one to elaborate on a number of in-depth considerations. It is sufficient to observe the root support of a canine and a diactor in order to understand the different functional requirements; one is developed for withstanding tangential loads, and the other is developed for dissipating orthogonal forces. The implant project will have to take these needs into account; otherwise, the peri-implant bone will ne geatively impacted, or in more unfortunate cases, the problems such as unscrewing or the fracture of the devices themselves will occur. On the other hand, an upper lateral incisor or the lower central incisors will have inferior root development as a consequence of their position and distance from the point of application of the masticatory force and the masticatory fulcrum (type III lever) [3,4].

This consideration is directly related to the dimensions of the implant to be inserted, which, therefore, should not depend only on the bone availability of the recipient site but also on the direct and indirect stress that the implant will undergo during chewing in the case of both the immediate load and after osseointegration. Further considerations may be necessary if several systems are designed, whether independent or joined together. It is worth mentioning that inclined implants work perfectly when placed in geometries of number that enhance their positions. On the other hand, creating an unfavourable angle between the prosthetic rehabilitation, the occlusal load and the implant device represents an extremely high biomechanical risk both for the recipient tissue and for the integrity of the device [5].

Another interesting aspect that should be evaluated concerns the choice and knowledge of the materials at our disposal for prosthetic rehabilitation. This choice is inlufenced by the economic aspect and previous considerations regarding the biotype, position in the oral cavity, and dimensions of the implant device, as well as any reciprocal connections and relationship with the antagonist. The rigidity of the chosen material represents an advantage in maintaining the results obtained over time (occlusal stability) and a disadvantage when, if not properly controlled, occlusal stress is transferred onto the device and its components. Paradoxically, patients whose condition can be controlled with frequency and regularity can be rehabilitated with any material, because any corrections required due to physiological changes in dental morphology and chewing can be implemented early, and these problems corrected before they develop into a trauma. On the contrary, if we suspect that it will not be possible to re-evaluate the chewing capacity regularly, there may be a need to use materials capable of following the evolution of human chewing dynamics [6].

On the other hand, the choice of the type of prosthetic product, either screwed or cemented, is not directly related to the biomechanical aspects. The first is particularly complex due to its management of passivation; however, when performed perfectly, it appears to be versatile and easily removable in contexts of both ordinary and extraordinary maintenance. The cemented prosthesis presents the well-known problem of a cementing material that has not been perfectly removed, even if it is erroneously considered to be simpler because, according to the protocols, it can be superimposed onto prostheses applied to natural teeth. In rare cases, failure to consider just one of these aspects leads to a severe or irreversible problem. However, in critical situations, a combination of several factors are often found to be responsible for failures unrelated to the biological or inflammatory aspects.

Implant–prosthetic planning performed simply upon radiological examination is often insufficient. Moreover, it seems that it is insufficient to standardize therapeutic projects and, if one proceeds with this method (for example, a rehabilitation with four lower implants with the two distal ones inclined), to develop the project by enabling the use of osseointegrate devices with dimensions and positions that satisfy and broadly meet the established biomechanical requirements. Biomechanical considerations remain crucial for the design and use of prostheses, and future research should focus on developing more sophisticated and versatile devices that are adaptable to changing body needs. Overall, the current orientations of surgical–prosthetic rehabilitation reflect the ongoing progress in the field and the promise of a brighter future for patients.

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References

1. Cervino, G.; Fiorillo, L.; Arzukanyan, A.; Spagnuolo, G.; Campagna, P.; Cicciù, M. Application Of Bioengineering Devices For The Stress Evaluation In Dentistry: The Last 10 Years Fem Parametric Analysis Of Outcomes And Current Trends. *Minerva Stomatol.* **2020**, *69*, 55–62. [CrossRef] [PubMed]
2. Chaskalovic, J. Finite element methods for engineering sciences. Theoretical approach and problem solving techniques. In *Translated and Extended Edition of the 2004 French Original*; Springer Science & Business Media: Berlin, Germany, 2008. [CrossRef]
3. Macedo, J.P.; Pereira, J.; Faria, J.; Pereira, C.A.; Alves, J.L.; Henriques, B.; Souza, J.C.M.; López-López, J. Finite element analysis of stress extent at peri-implant bone surrounding external hexagon or Morse taper implants. *J. Mech. Behav. Biomed. Mater.* **2017**, *71*, 441–447. [CrossRef] [PubMed]
4. Lin, P.-J.; Su, K.-C. Biomechanical Design Application on the Effect of Different Occlusion Conditions on Dental Implants with Different Positions—A Finite Element Analysis. *Appl. Sci.* **2020**, *10*, 5826. [CrossRef]
5. Vayron, R.; Nguyen, V.H.; Bosc, R.; Naili, S.; Haïat, G. Assessment of the biomechanical stability of a dental implant with quantitative ultrasound: A three-dimensional finite element study. *J. Acoust. Soc. Am.* **2016**, *139*, 773–780. [CrossRef]
6. Zhou, W.; Rong, Q.; An, J.; Zhang, Y. Finite Element Analysis of Two- and Three-Dimensional Fixation in Treating Mandibular Symphyseal Fracture Combined With Bilateral Condylar Intracapsular Fractures. *J. Craniofac. Surg.* **2021**, *32*, 2557–2561. [CrossRef] [PubMed]