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Special Issue Reprint

Advancements in Prosthodontics

Exploring Innovations in Rehabilitation Medicine

Edited by
Kelvin Ian Afrashtehfar

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Advancements in Prosthodontics: Exploring Innovations in Rehabilitation Medicine

Guest Editor

Kelvin Ian Afrashtehfar

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About the Editor

Kelvin Ian Afrashtehfar

Prof. Dr. Kelvin Afrashtehfar is a Canadian Board-Certified Specialist in Prosthodontics, currently serving as a research faculty member at the University of Bern (Switzerland) and adjunct clinical instructor at the Implant Dentistry–Study Consortium (IDSC) in Dubai. His clinical practice is limited to complex implant and esthetic rehabilitation, with a focus on evidence-based decision-making and interdisciplinary care. Dr. Afrashtehfar holds advanced degrees in prosthodontics and dental sciences from the University of British Columbia, McGill University, and the University of Bern. His research includes digital dentistry, dental materials, and artificial intelligence applications in prosthetic treatment planning. Recognized internationally, he has been ranked among the top 2% of scientists worldwide for several consecutive years, according to Stanford's citation-based metrics. As the Guest Editor of this Special Issue, Dr. Afrashtehfar brings together global expertise and translational insights to highlight innovative strategies in prosthodontic rehabilitation. He remains committed to bridging research and clinical practice through mentorship, collaborative projects, and scholarly contributions.

Preface

This Special Issue reprint, *Advancements in Prosthodontics: Exploring Innovations in Rehabilitation Medicine*, brings together a curated selection of research and clinical perspectives that reflect the ongoing transformation in prosthodontics through technological, digital, and biomaterial innovations. Its scope spans implant and removable prosthodontics, CAD/CAM protocols, AI-driven diagnostics, and biomechanical analyses—offering a comprehensive snapshot of emerging trends that are redefining modern oral rehabilitation.

The purpose of this collection is to present a multidisciplinary synthesis of state-of-the-art solutions addressing both functional and esthetic challenges in prosthetic dentistry. The contributing authors include clinical specialists, academic researchers, and biomedical engineers from leading institutions worldwide who collectively provide invaluable insights into cutting-edge techniques and materials.

This reprint is addressed to clinicians, researchers, educators, and postgraduate students seeking to deepen their understanding of contemporary prosthodontics and its integration with digital and regenerative medicine.

I extend my sincere gratitude to all authors for their scholarly contributions, to the reviewers for their meticulous evaluations, and to the editorial team at *Prosthesis* for their invaluable assistance in bringing this Special Issue to fruition.

Kelvin Ian Afrashtehfar
Guest Editor

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Editorial

Artificial Intelligence in Reconstructive Implant Dentistry—Current Perspectives

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In recent years, artificial intelligence (AI) has emerged as a transformative force in reconstructive implant dentistry. The integration of AI technologies into various aspects of dental practice, including digital data acquisition, treatment planning, and prognosis evaluation, offers unprecedented opportunities to enhance precision, efficiency, and clinical outcomes. Indeed, AI applications in implant dentistry span a broad spectrum of functionalities, from enhancing digital data acquisition and integration to providing sophisticated tools for treatment planning and prognosis evaluation. These technologies have the potential to streamline workflows, reduce human error, and improve the accuracy of clinical decisions, ultimately leading to better patient care. Therefore, this commentary synthesizes findings from recent studies by three well-regarded consultant prosthodontics and implantology professors affiliated to different Emirati academic institutions, trained in Switzerland, Canada, Germany, and the United Kingdom, to provide an overview of cutting-edge AI applications in reconstructive implant dentistry. Key areas of focus include digital data acquisition technologies, bone quality assessment, automated tissue segmentation, implant fixture identification and classification, and predictive analytics for implant planning and prognosis.

In terms of digital data acquisition and integration, AI-enhanced digital data acquisition technologies, including facial scanners (FSs), intraoral scanners (IOSs), and cone beam computed tomography (CBCT) devices, facilitate accurate data collection and integration. Revilla-León et al. [1] emphasize the role of AI in the automatic alignment, noise reduction, and segmentation of anatomical structures. These advancements streamline the creation of comprehensive virtual patient models, enhancing treatment planning accuracy. Indeed, AI-driven automated tissue segmentation significantly accelerates treatment planning. Liu et al. [2] introduced a fully automated system for segmenting oral surgery-related tissues from CBCT images, achieving a high accuracy in identifying alveolar bone, teeth, and maxillary sinus. These advancements reduce the manual segmentation effort and enhance surgical precision. For instance, Hartoonian et al. [3] reviewed AI applications in dentomaxillofacial imaging, showing the potential to improve diagnostic accuracy and treatment planning. Elgarba et al. [4] validated a cloud-based convolutional neural network for the automated segmentation of dental implants, demonstrating high performance and efficiency. A systematic review by the Afrashtehfar group demonstrated that coDiagnostiX® Digital Implant Treatment Planning Software (Dental Wings GmbH in Düsseldorf, Germany) outperforms other systems in implant treatment planning [5]. These advancements facilitate accurate and efficient clinical workflows, improving overall care quality [6–12].

Accurate bone quality assessment is crucial for successful dental implants. Lee et al. [13] demonstrated that deep learning (DL) models effectively evaluate bone quality from panoramic radiographs, correlating significantly with CBCT measurements and implant surgeons' tactile assessments. This AI application enhances objectivity and precision in bone quality evaluation, which is essential for implant stability and osseointegration. Furthermore, AI algorithms enhance implant planning by detecting edentulous areas and evaluating bone dimensions. Alqutaibi et al. [14] reported the high accuracy of AI-based diagnostic tools in implant planning, while Wu et al. [15] demonstrated the potential of AI in predicting implant prognosis. These predictive analytics tools help identify potential complications, optimizing treatment outcomes.

AI models demonstrate high accuracy in identifying and classifying dental implant fixtures from radiographs. Ibraheem [16] showed the utility of AI in implant identification, which is crucial for the continuity of care when previous records are unavailable. This capability improves clinical efficiency and reduces identification errors. Moreover, Lubbad et al. [17] compared deep learning models for classifying dental implants, and found that ConvNeXt models achieve the highest classification accuracy. Similarly, Mangano et al. [18] explored AI and augmented reality (AR) for guided implant surgery, demonstrating effective 3D planning and execution. Sakai et al. [19] developed an AI model to support implant drilling protocol decisions, showing significant accuracy in predicting appropriate protocols from CBCT images. These models increase precision in implant placement and the predictability of surgical outcomes.

The significant improvement in accuracy and efficiency AI provides is common across these studies, whether in data acquisition, segmentation, or implant identification. However, differences arise in the specific methodologies and AI models employed, such as the use of deep learning architectures like ConvNeXt [17] versus traditional machine learning algorithms [16]. Additionally, the extent of automation varies, with some studies achieving fully automated workflows [2,4], while others still require significant manual input [14,19]. Critically, while AI shows promise, challenges remain. For instance, the generalizability of AI models across diverse patient populations and varying clinical conditions needs further exploration. Studies like those by Wu et al. [15] and Alqutaibi et al. [14] conclude that there is a need for high-quality datasets and rigorous validation to increase reliability and reduce biases. Moreover, ethical considerations, including data privacy and the potential for algorithmic biases [20,21], must be addressed to fully integrate AI into clinical practice.

In conclusion, the integration of AI into reconstructive implant dentistry represents a significant advancement in the field. AI technologies offer enhanced diagnostic capabilities, streamlined workflows, and improved clinical outcomes. However, challenges such as the need for high-quality datasets, the rigorous validation of AI models, and addressing potential biases in AI algorithms remain. Future research should focus on refining these technologies, expanding their clinical applications, and ensuring their reliability and generalizability in diverse patient populations. This can lead to superior patient care and treatment success. As AI technologies continue to evolve, they hold the promise of transforming dental practice, making implant procedures more predictable and successful.

Conflicts of Interest: The authors declare that there are no conflicts of interests.

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Article

Comparison between Bone-Level and Tissue-Level Implants in Immediate-Loading Full-Arch Rehabilitations: A Retrospective Multi-Center 1-Year Follow-Up Study

Francesco Pera [1,†], Massimo Carossa [1,*,†], Francesco Bagnasco [2], Armando Crupi [1], Giulia Ambrogio [1], Gaetano Isola [3], Maria Menini [2,‡] and Paolo Pesce [2,‡]

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Abstract: The objective of the present retrospective multi-center study was to analyze the outcomes of bone-level (BL) implants and tissue-level (TL) implants in immediate-loading full-arch rehabilitations. Patients who were previously rehabilitated with full-arch immediate-loading rehabilitations with either BL or TL implants were considered. Data regarding implant survival rate, marginal bone loss (MBL), peri-implant probing depth (PPD), plaque index (PI), and bleeding on probing (BOP) were recorded, and the 1-year follow-up data were statistically analyzed between the two groups. In total, 38 patients were evaluated for a total implant number of 156 (n = 80 TL implants and n = 76 BL implants). An implant survival rate of 97.37% was recoded for the BL group while an implant survival rate of 100% was noted for the TL group. A total MBL of 1.324 ± 0.64 mm was recorded for BL implants, while a total MBL of 1.194 ± 0.30 mm was recorded for TL implants. A statistically significant difference was highlighted regarding MBL at the mesial aspect ($p = 0.01552$) of the implants, with BL implants presenting with higher MBL. Within the range of acceptable healthy values, a statistically significant difference was also highlighted regarding BOP ($p < 0.00001$), with TL implants presenting higher values. No statistically significant difference ($p > 0.05$) was recorded for any of the other variables analyzed. Within the limitations of the present retrospective study, both TL and BL implants seem to provide good clinical outcomes after a 12-month observational period when employed in immediate-loading full-arch rehabilitation.

Keywords: dental implants; immediate loading; full-arch; bone-level; tissue-level; abutments

1. Introduction

Nowadays, immediate-loading full-arch implant rehabilitation represents the elective treatment plan for the fixed rehabilitation of patients suffering from edentulism or with residual terminal dentition [1], offering them a transformative solution with profound implications for both their oral health and quality of life [2–4]. Unlike traditional delayed implant techniques that involve prolonged waiting periods, immediate-loading full-arch implant rehabilitation allows for the insertion of dental implants and rehabilitation with a fixed full-arch prostheses within 24–48 h after surgery [5,6]. This groundbreaking approach not only provides patients with an immediate restoration of their smile and oral function but also significantly reduces treatment time. However, despite high long-term survival rates [1,5], complications continue to be undesirable events [7–9], and therefore, research on the topic remains prominent.

Traditionally, implants were initially proposed in the morphology of Branemark implants as bone-level (BL) implants presenting an external connection [10]. This connection has been widely used and studied [11,12]. It is reported to present different advantages, such as an optimal passive-fit with the prosthesis [13] and better management facility in case of multiple implants [14]. However, over the years, some criticism has been raised, linked to the fact that this connection type may exhibit slight micro-movements between components, potentially affecting long-term stability [15,16] and increasing the risk of complications such as screw loosening and bacterial micro-leakage [17].

To avoid these possible complications, internal connections, also commonly adopted as BL implants, were later introduced, aiming to improve the implant–prosthetic mechanical stability by minimizing micro-movements between the implant components [18]. This stability was reported to be particularly crucial in full-arch rehabilitations where multiple implants need to work together to distribute the load effectively [14]. Furthermore, the internal connection led to the development of the platform switching concept [19] in which decreasing the diameter of the abutment in relation to the connection diameter provides increased space for the peri-implant soft tissue. As a consequence, the sealing around the implant's neck is improved, with the goal to better preserve the marginal bone level [19].

To date, different articles have investigated and compared the usage of BL implants with external and internal connections in immediate-loading full-arch rehabilitation [20,21]. Menini et al. [20] and Pera et al. [21] followed for 1 year and 3 years of follow-up, respectively, 20 full-arch rehabilitations supported by internal or external connections. According to their findings, no variations in the peri-implant soft and hard tissue were highlighted between the two connection designs, and therefore, both the designs can be considered clinically reliable for this type of rehabilitation.

Furthermore, another implant design called tissue-level (TL) implant with a convergent collar was introduced in contrast to the above-mentioned traditional BL implants [22,23]. Unlike their BL counterparts, where the most coronal part of the implant is positioned at the bone level, TL implants are characterized by their collar, which emerges at or just above the level of the mucosal tissues. Therefore, this implant design is composed altogether by the implant body that is placed into the bone and by the collar that serves as a trans-mucosal component. Among its advantages, this implant design is reported to avoid the presence of possible micro-gaps in the trans-mucosal area [24] and to increase soft tissue sealing, minimizing irritation and inflammation of the surrounding gums while promoting healthy soft tissue integration and long-term stability [23]. The increased soft tissue sealing is obtained by moving the prosthetic platform at the coronal level of the soft tissue and, therefore, the possible damages of the tissues during the prosthetic procedures are avoided [24]

Currently, few articles are available on the employment of TL implants in immediate-loading full-arch rehabilitations [24,25]. According to the available results, this implant design appears to be a viable option, even for the rehabilitation of fully edentulous patients.

However, to the authors knowledges, while different articles compared TL implants and BL implants in single- [23,26] and multi-unit [27] rehabilitations, no previous articles are available comparing these two implant designs in immediate-loading full-arch rehabilitations.

Therefore, the first objective of the present article was to retrospectively compare the outcomes of BL implants and TL implants in immediate-loading full-arch rehabilitations. The second objective was to analyze possible factors influencing marginal bone loss (MBL) including implant diameters and lengths, type of abutment, jaw distribution, and implant inclination. The first null hypothesis was that no clinical outcome differences are present between the two implant designs. The second null hypothesis was that no differences in MBL exist between the different subgroups analyzed in the study.

2. Materials and Methods

Patients who were previously rehabilitated with full-arch immediate-loading rehabilitation with either BL or TL implants at the University of Turin and University of Genoa were evaluated for the present study at the 1-year follow-up. The present research was performed following the Declaration of Helsinki. All the participants signed an informed consent form. The present study was approved by the local ethical committee of the University of Genoa (protocol n. 527) and of the University of Turin (protocol n. 0130929). The present study was reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

2.1. Patient Selection

All the patients initially presented with residual dentition with unfavorable prognosis, either in the mandibular or in the maxilla, and were seeking immediate fixed rehabilitations. Bone availability was evaluated based on ortopantomography and Tc cone beam. After the clinical and radiological evaluation, patients who were found eligible were then rehabilitated with an immediate-loading implant-supported full-arch rehabilitation.

Patients who met the following inclusion/exclusion criteria were enrolled in the present study.

Inclusion criteria: Age $\geq$ 18 years; previously rehabilitated with immediate-loading full-arch rehabilitation with BL or TL implants; systemically healthy. Exclusion criteria: smokers; requirement of bone regeneration procedures; presence of diabetes; intake of drugs that could possibly interfere with bone remodeling and healing; previous radiotherapy of head and neck area; inability to attend the control visit.

2.2. Study Design

Firstly, implants were divided into two primary groups based on the division between BL implants (Group 1) and TL implants (Group 2).

Secondly, macro-topography of the implants—including implant length and diameter—jaw distribution (mandible vs. maxilla), implant inclination (tilted vs. axial), and abutment type with different inclinations were considered as subgroups.

2.3. Surgery Procedures

The workflow adopted (Columbus Bridge Protocol, CBP), including the surgical and prosthetic aspects, is reported in detail in previously published articles [5].

All the surgeries were performed by two experienced surgeons (one per center) specialized in implant surgery. Patients underwent professional oral hygiene on the day prior to surgery, including scaling and root planing to decrease the bacterial load of the mouth. Pre-operative antibiotic coverage with Amoxicillina 875 mg + Clavulanic acid 125 mg every 12 h for 6 days was prescribed [28,29], beginning one day before the surgery appointment. Chlorhexidina digluconate solution was provided to the patient to rinse for one minute prior to start the surgery.

A dose of 4% articaine with 1:10.000 adrenaline (Alfacaina SP; Dentsply Italy, Rome, Italy) was used to locally perform anesthesia. Patients who presented with residual terminal dentition underwent teeth extractions, and residual sockets were carefully debrided. A full thickness mucoperiostal flap was elevated. Four to six implants, based on the bone availability, were then inserted. Implant sites were prepared with dedicated drills following the manufacturer's instructions. BL implants (Syra or Shelta implants, Sweden & Martina, Due Carrare, Padova, Italy) or TL implants (Prama, Sweden & Martina, Due Carrare, Padova, Italy) were used (Figure 1).

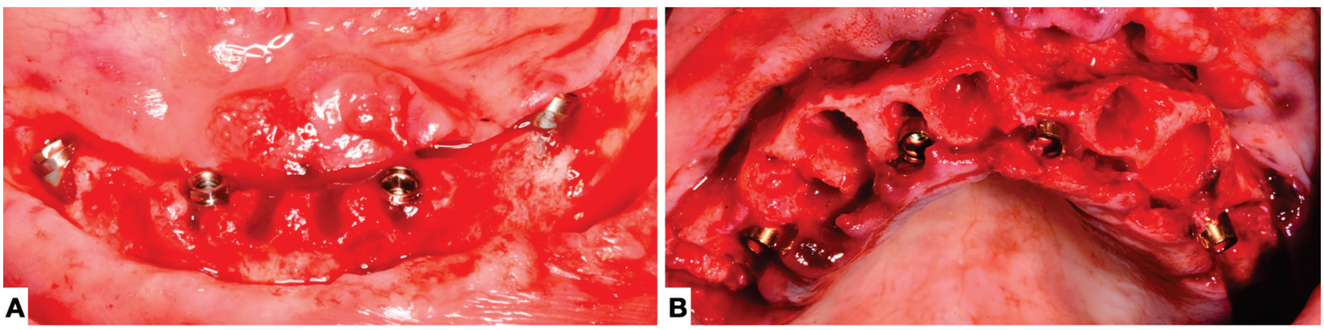

Figure 1. Clinical images after the surgical insertion of the implants: (**A**) bone-level implants; (**B**) tissue-level implants.

The two frontal implants were inserted straight, and the two posterior implants were tilted when necessary to avert the anatomical boundaries (alveolar nerve and sinus) following the CBP [5]. The length and diameter of the inserted implants were decided according to the bone availability evaluated on X-rays (ortopantomography and Tc cone beam) acquired prior to the surgery. BL implants were all connected to either straight or angulated abutments (PAD, Sweden & Martina, Due Carrare, Padova, Italy), while TL implants were connected to angulated abutments (PAD 330-303, Sweden & Martina, Due Carrare, Padova, Italy) in the posterior tilted implants and left with no abutment in the frontal straight implants (Figure 2).

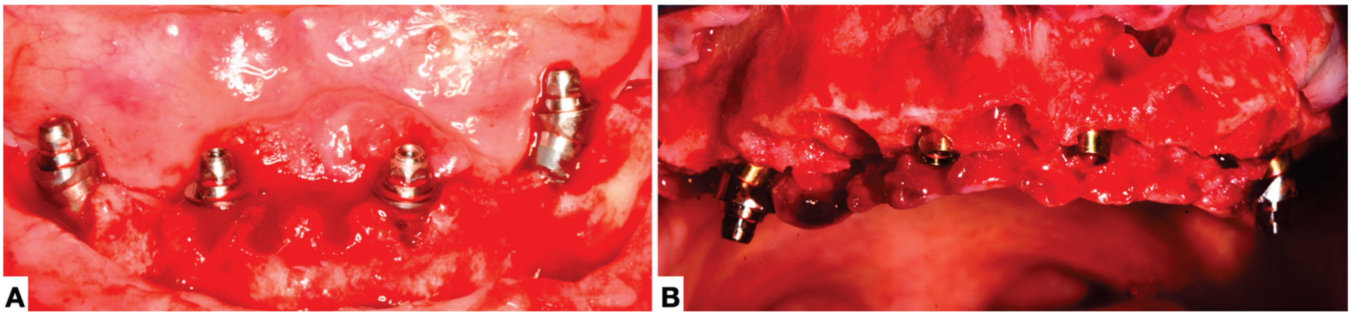

Figure 2. Clinical images after insertion of the abutments. (**A**) Bone-level implants; the two posterior tilted implants are linked to angulated abutments, while the two straight frontal ones are linked to straight abutments. (**B**) Tissue-level implants; the two posterior tilted implants are linked to angulated abutments, while the two straight frontal ones are left without abutments.

Sutures were made using silk multifilament (PERMA-HAND SILK 4-0, Ethicon, Somerville, NJ, USA). Impressions were made using open tray and impression plaster (BF-Plaster Dental, Turin, Italy). Post-operative instructions including soft diet and hygienic instructions were provided to the patients. Provisional screw-retained full-arch prosthesis made of resin with a metal framework was delivered to the patients within 24–48 h after the surgery. Peri-apical X-rays were acquired. Patients returned for suture removal one week after the surgery (Figure 3).

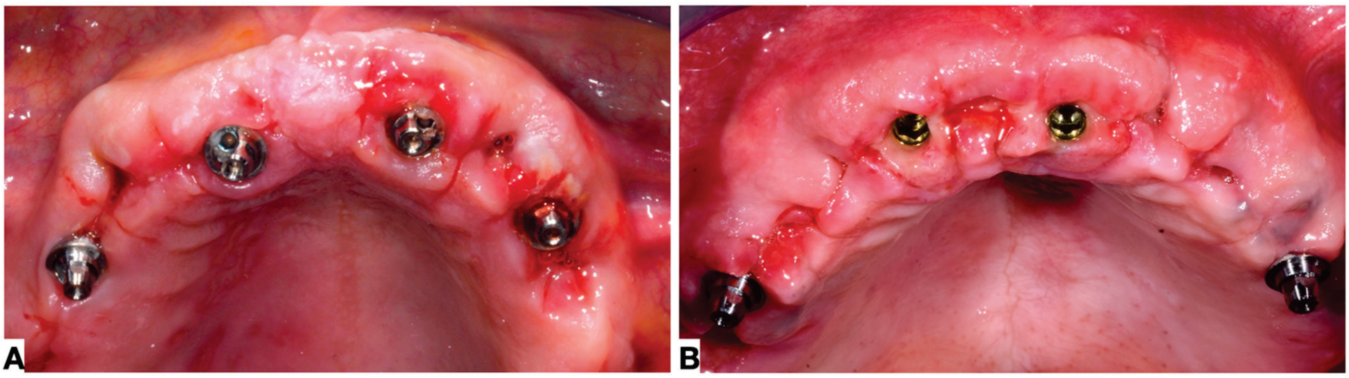

Figure 3. Clinical images at the sutures removal appointment one week after the surgery: (**A**) bone-level implants; (**B**) tissue-level implants.

Six months after the surgery, a new analogic impression (open-tray) was taken, and final composite with metal framework screw-retained prostheses was then fabricated and delivered. Patients were then evaluated for the present study 12 months after surgery and follow-up periapical X-rays were acquired.