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Primary Stability of Short Dental Implants is Affected by the Length of the Implant and the Depth of the Insertion: An Investigation of a Novel Artificial Bone Mandible Model in Vitro

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Abstract

Dental implants, in contrast to orthopedic implants, necessitate the coordination of both osseointegrations at the bone-implant interface and soft-tissue integration at the transmucosal region in a complex oral microenvironment populated by numerous pathogenic bacteria. This presents a very challenging setting for the early acceptance of dental implants and their long-term survival, particularly in vulnerable patient populations like diabetics, smokers, and the elderly. New nano-engineering techniques are emerging to enable advanced local therapy from the surface of titanium-based dental implants. For maximum localized therapeutic effect, this includes anodized nano-engineered implants containing growth factors, antibiotics, therapeutic nanoparticles, and biopolymers. Finding a balance between therapy and bioactivity enhancement (like bactericidal efficacy) without causing cytotoxicity is a crucial criterion. In order to make it possible for these therapeutic dental implants to be used in clinical settings, significant research gaps must still be filled. In order to enable the successful fabrication of clinically-translatable therapeutic dental implants that would permit long-term success, even in compromised patient conditions, this review provides information on the most recent developments, obstacles, and future directions in this field.

Keywords: Implants for teeth; Bactericidal efficacy;Supplying drugs; Atomization; Nanotubes

Introduction

It has been demonstrated that global tooth loss rates range from 1.71 percent to 9.19 percent, indicating that oral health issues remain a neglected health issue. Multiple diseases can cause tooth loss, which dramatically lowers quality of life through diminished aesthetic appearance, difficulty speaking, and the loss of chewing function. Previously, dentures had to be stabilized using the patient's healthy teeth or soft tissue as the primary treatment option for this issue [1]. As the standard treatment for tooth loss, dental implants are replacing dentures. Dental implants, also known as "artificial tooth roots," are metal posts that are surgically inserted under the gingiva into the upper or lower jaw to support artificial crowns that replace missing teeth. Dental implants have been used for a long time to support the restoration of a lost tooth.

Metallic materials have been used in orthopedics for more than fifty years. In the first study on the use of commercially pure (cpTi) for medicine was published. Animal tests showed that it is very biocompatible with bone. Today, bone fixators, artificial joints, dental implants, and other applications make extensive use of titanium (Ti) and its alloys. cpTi has been used successfully for dental implants since the middle of the, and its biocompatibility with hard tissues is well known [2]. Ti and its alloys are more biocompatible and non-toxic than stainless steel and chromium-cobalt for dental applications. Additionally, Ti has the ability to rapidly react with oxygen, resulting in the formation of a layer of titanium oxide (TiO2) that protects the metal surface from corrosion. Dental implants are built on Ti biomaterials because of these factors.

Dental implants that are inserted into the alveolar bone take between three and six months to heal (osseointegration). Fruitful osseointegration following implantation is fundamental for the dental embed to actually work. One of the factors that contributes to progressive marginal bone loss during osseointegration under compromised local or systemic conditions is poor implant-bone contact. In a typical environment, Ti-bone contact is durable, resilient, and resistant to bone resorption after healthy osseointegration. Implant failure—both early and late—could be the final result of a decline in systemic health, bacterial accumulation, or trauma, necessitating implant removal [3]. Early failure is when dental implants fail to osseointegrate, while late failure is when either the osseointegration that is already present or the function of the implants fails. Early implant failure is primarily caused by surgical stress, a lack of primary stability, and perioperative contamination. Contrarily, the most significant factors associated with late implant failure are peri-implantitis and overloading. Additionally, dental implants are distinguished by the presence of a transmucosal portion that penetrates the soft tissue in the space between the prosthesis and the bone. As a result, in addition to proper osseointegration, firm and consistent soft-tissue integration (STI) is required for dental implants to function effectively over time.

The clinical preservation of implants is dependent on the upkeep of peri-implant tissues even after adequate osseointegration. As a result, implant treatments' long-term success may be significantly influenced by the degree of peri-implant bone loss. Physiologic bone resorption is estimated to range from 1.5 to 2 millimeters the first year after the implant is loaded and to 0.2 millimeters each year thereafter. It has been demonstrated that patient-specific factors, such as systemic health and dental care, as well as adverse load, surgical trauma, peri-implantitis, implant positioning, implant size and roughness, opposing occlusion,

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misfitting of the implant and the prosthesis, and prosthetic design, all contribute to marginal bone loss around implants over time [4].

Due to the widespread use of dental implants, peri-implant diseases like peri-mucositis and peri-implantitis have been linked to progressive failures. As an immediate result, the administration of peri-implantitis has formed into a continuous trouble for regular clinical practice. The pathological condition known as peri-implantitis is connected to the biofilm that affects the soft and hard tissues that surround implants and causes bleeding, suppuration, and bone loss. The design of the implant, the surface topography or roughness, the condition of the surrounding tissue, and the surgeon's level of expertise all play a role in determining the cause of peri-implantitis [5]. Despite the fact that plaque deposition is the primary etiologic factor in both periodontitis and peri-implantitis, the different topographical characteristics of each implant make treating peri-implantitis more challenging.

Different careful and non-careful embed disinfecting approaches have been portrayed to wipe out biofilms from the embed surface. The most common non-surgical treatments for peri-implantitis are antibiotic or antiseptic prescriptions, mechanical debridement techniques, and laser applications. Reconstructive surgery, on the other hand, is a component of surgical procedures. When performing a non-surgical or surgical peri-implant treatment, a methodical approach should be taken, starting with the simplest treatment and moving on to more in-depth ones.

The clinician must be familiar with the systemic and local risk factors that may affect the success of dental implants in order to carry out a thorough analysis of the patient population. The implant's future may be affected by the patient's health and social habits, such as smoking, diabetes, and osteoporosis. Implant failure is also significantly influenced by a history of periodontitis. Risk factors and methods for modifying or eliminating them should be taught to patients. A comprehensive picture of a patient's health cannot be obtained without medical consultation when it comes to systemic disorders. For the diagnosis of implant failure, the early clinical signs of infection, pain or soreness, a non-blunt sound on percussion, radiographic findings, implant movement, and bleeding on probing are crucial. In order for doctors to quickly decide on a course of treatment, the aforementioned symptoms must be easily distinguished [6].

From the perspective of implant manufacturing, the search for improved bone regeneration in adverse conditions has contributed to the ongoing improvement of modern dental implants. This is the result of more than two decades' worth of research on topics like implant macro, micro, and nano design and material selection.

Compromised patient conditions and the requirement for local therapy

Osseointegration and long-term use of dental implants have been demonstrated to be successful as a result of various design advancements. In spite of the fact that the survival rate of dental implants in edentulous patients has been documented to be greater than 90% over a ten-year monitoring period, impaired conditions, which typically occur in old age, hinder the overall success of implant therapy. Dental implant patients are more likely to be older in the future as the average lifespan rises, making them more vulnerable to systemic illnesses and risk factors that slow down recovery.

The long-term success of implant therapy can be affected by other contributing factors, including local or systemic diseases. As a result, there are a number of these variables that should not be used for implant placement [7]. Major bleeding issues, recent life-threatening surgery, drug addiction, certain mental conditions, intravenous bisphosphonate therapy, and active cancer treatment are all contraindications to the placement of dental implants. Alveolar bone regeneration may also be affected by a number of bone disorders, such as osteoporosis and osteogenesis imperfecta. Utilizing corticosteroids or antiresorptive treatment regimens in the management of these diseases also has a negative impact on bone quality. Uncontrolled diabetes, radiotherapy, smoking, HIV (human immunodeficiency virus), some hereditary diseases, autoimmune disorders, chronic renal diseases, poor dental hygiene, and previous periodontal disease are additional risk factors that influence the success of implant surgery. Summarize the ongoing patient conditions that threaten the long-term success of dental implants.

Patients who had osteoporosis in the past, especially those taking bisphosphonates, had lower bone densities and took longer to recover. Osteoporosis patients may be able to avoid this by taking hormones and other adjuvants; However, these medications also slow down the metabolism of bone. Implant failure and the body's natural healing process may be hampered if certain medications, such as those prescribed to cancer patients, are taken for an extended period of time. The risk of developing osteoradionecrosis in chemotherapy and radiation patients is quite high. Tissue repair was reduced and bone marrow suppression was demonstrated in this condition. Additionally, it has been demonstrated that unfavorable occlusion and unbalanced mechanical factors may also impede bone healing and implant treatment outcomes in individuals with macroglossia and crossbite.

In situations where there is insufficient bone metabolism, osseointegration may benefit from coating implant surfaces with various osteogenic chemicals [8]. To accomplish this, various substances like bone morphogenetic proteins (BMPs), vascular endothelial growth factor (VEGF), extracellular matrix proteins (ECM), hydroxyapatite, and metals were used to manufacture implant surface coatings. Bisphosphonates, selective estrogen receptor modulators (SERMs), and receptor activator of nuclear factor-kB ligand (RANKL) antibodies are examples of drugs used to treat or prevent osteoporosis. They are also coated to increase osseointegration and decrease bone resorption. Studies have also looked into selecting implants with active surfaces that are hydrophilic, sandblasted, acid-etched (SLA), and micro- and nanostructured, as well as coating the surfaces with compounds like strontium and calcium phosphate.

When treating people with uncontrolled diabetes mellitus, there is also a significant failure rate of implants. Diabetes patients experience deterioration in bone health and blood and tissue fluid dynamics. Diabetes's pathophysiology includes elevated blood glucose levels that lead to abnormalities and cellular stress. In patients with poorly controlled diabetes, dental implant treatment should be delayed until glycaemic control is stabilized before proceeding. In order to avoid developing peri-implant disease, these patients must receive appropriate dental hygiene instruction in addition to taking antibiotics and managing their diabetes on a regular basis. In diabetes, a weakened immune system may also increase bacterial load and cause infection. Applying a bacteriostatic and calming covering to the outer layer of an embed is viewed as a legitimate methodology for resolving this issue.

Periodontitis is categorized using a comprehensive staging and grading system, along with its severity and the complexity of the necessary treatments. Stage IV of periodontitis, the most severe stage, is characterized by a number of clinical features linked to the severity of the condition. Periodontitis is more likely to result in tooth loss in Stage IV patients than in Stage I patients. Periodontal disease has been linked to a lower implant success rate and an increased risk of peri-implant diseases, according to research. Using surfaces that have been modified or coated with bactericidal substances, ongoing research is being carried out to either treat or prevent peri-implantitis. These bactericidal agents include silver, copper, and zinc coatings on the surfaces of Ti implants. Biomimetic dental implants with antibacterial properties may help prevent peri-implantitis in people who have a history of periodontitis.

It has been demonstrated that smoking is a significant factor in the onset of numerous illnesses that pose a threat to one's life. There is widespread agreement that smoking has a negative impact on restorations supported by implants, and that smoking is a well-known risk factor for implant failure and peri-implantitis. It has been demonstrated that smoking accelerates the process of bone loss and slows the recovery of bone tissue. If the patient smokes, it is more difficult to successfully place dental implants on type IV bone. Due to the influence of microstructure and other variables, smokers may gain improved bone apposition more than others.

Dental implants made of nanotechnology

Bioactivity and local therapy the most common nanomaterials used in dentistry are nanocomposites, nanoparticles (also known as tubes or fibers), antimicrobial coatings, and nano coatings [9]. Their sizes range from one to one hundred nanometers. The goal of dental implant nano-engineering is to create isotropic or anisotropic nanoscale features that, with or without the ability to allow local drug delivery, would enable bactericidal functions or stimulate cell bioactivity to improve implant integration. The nanoscale embed surface can prompt an adjusted/upgraded physicochemical (bone or delicate tissue holding) or biochemical (protein/cell attachment, cell conduct) reaction. The next generation of dental implants made of titanium that have been modified through anodization to produce controlled biocompatible titania nanocoatings for use as therapeutic implants will be the focus of this review.

Modification of the surface

Dental implants are undergoing physical, chemical, and electrochemical surface modification in an effort to enhance bioactivity and provide therapy geared toward long-term success. Machining, grit-blasting, acid-etching, sandblasting and acid-etching, anodization, and plasma treatment are some of the implant surface treatments that are used in clinical settings [10]. Based on landmark studies conducted by P.I. Brunemark and colleagues, machining is regarded as the pioneering modification technique for dental implants. Harder metals are used to deform the base material at high rotation speeds, resulting in macro- to micro-scale features that have gone from being manually controlled to being digitally controlled. Next, grit-blasting involves using a high-pressure, high-speed blaster to bombard the implant material with hydroxyapatite (HA) or Ti, Al, or Al_2O_3 particles, creating micro- and nanoscale indentations on the material with characteristics determined by the size and type of the particles. Acid-etching, which was initially developed to get rid of implant manufacturing residues, can be used to make roughened (micro/nano) surfaces, but standardization is needed to control implant topography. SLA, which stands for "sandblasted large grit acid etched," is a popular choice for implants in clinical settings. On the surface of micro/nano SLA implants, studies have demonstrated accelerated orchestration of osseointegration within one to two months. Due to its long-term success in both preclinical and clinical studies, this dual physical and chemical process is regarded as the most efficient method for modifying the surface of dental implants. SLA implants differ from company to company, making comparison difficult.

Materials and Method

Artificial bone specimen and dental implant preparation

In this study, an edentulous composite bone with 17 PCF solid-foam cancellous cores and mandibles with cortical bone (1.64 g/cm3) was used [11]. Notably, the inferior alveolar nerve was modeled in addition to the human bone's properties in the artificial bone model used in this study. Additionally, a short commercial dental implant dimension was chosen.

Grouping based on various parameter settings

In the current study, the insertion method was used to create three groups. There were seven samples in each group. After an implant was inserted into an artificial mandibular bone specimen, CBCT images were taken to ensure that the insertion site was correct. Each of these three groups contained seven implants, for a total of 21 implants. Three and four implants were placed in the first and second molar positions, respectively, in each group.

Group 1: 6-millimeter implant placed equicrestally.

Group 2: 6-mm implant placed 1.5-mm below the subcostal surface.

Group 3: With a lateral lingual cortical plate anchorage, a 6-mm implant is inserted.

The CBCT images used to prepare the surgical guide were used to prepare the mandibular artificial bone specimens [12]. By comparing the planned implant's position to the actual specimen's position using CBCT images, specialized software verified that the surgical guide was accurate. For the purpose of this investigation, a number of tooth positions in the posterior mandibular region were chosen. The following scanning parameters were used for the dental CBCT imaging: Orthophos SL 3D (Dentsply Sirona, Bensheim, Germany). a voltage of 85 kV, a resolution of 80 micrometers, and a current of 7 mA.

Measurement of four primary stability indices for short dental implants

The designed surgical guide was used to measure four primary stability indices for short dental implants. The implant site osteotomy was performed. A Nobel Biocare OsseoSet implant motor with a 20-rpm rotating speed was used to insert an implant after a mandibular bone specimen was secured to a custom fixture. The engine could record the quick force (per millisecond) created during the embed technique. The primary stability of an implant after its abutment was placed was measured using a Periotest device. The tip of the Periotest device was 2 mm away from the abutment and perpendicular to it. ISQ values were also gathered using a resonance frequency analyzer. The brilliant stake of the interior hex association of an embed was gotten to the highest point of the embed.

Result and Discussion

In the past, dentists were unable to insert the right-sized dental implants because there was insufficient bone mass in the edentulous area as a result of long-term tooth loss or other factors. Due to the anatomical restrictions imposed by the maxillary sinus and inferior alveolar nerve, this issue is particularly severe in the molar region. In order to insert a dental implant with sufficient length, practitioners frequently required bone augmentation procedures. The development of short implants, which are increasingly being used on patients with anatomical limitations to avoid the need to perform complex procedures, and advancements in dental implant designs and surface treatments have led to massive improvements in implant success rates [13]. However, very few studies have investigated the effects of insertion depth on primary stability and the primary stability of short implants. Four primary stability indicators are used for the first time in this study. The findings indicate that maximum insertion torque and final insertion torque are not always attained at the same insertion depth during the insertion of a dental implant, and that torque increases initially and decreases thereafter. As a result, the primary stability of a dental implant may be better assessed using the FITV. The present study also demonstrated that the loss of cortical engagement results in a significant decrease in the implant's ISQ, PTV, and FITV when a dental implant is inserted past the cortical bone layer. A dental implant's primary stability is dependent on the cortical bone.

For testing the biomechanics of implants, a lot of researchers have used artificial bones or fresh animal bones as materials [14]. However, each of these two testing materials has its own set of drawbacks. Mandibular artificial bone models and artificial bone blocks are two types of artificial bones that are more prevalent on the market. The mechanics of human bone can be stimulated by artificial bone blocks, but the appearance of human jawbones cannot be altered. The mandibular artificial bone models, which look like the mandible, are made of the same material and can't show the difference between cancerous bone and cortical bone. Additionally, each animal bone specimen has slightly distinct material properties, and they do not resemble the human mandible in appearance when used. The cortical and cancerous bones of the artificial mandibular bones used in this study have a density and elastic modulus that are comparable to those of the human jawbone demonstrated that the average thickness of the cortical bones in the human mandible is 2.22 0.47 mm [15]. Our artificial bone had a thickness of 2.0–2.5 mm, which is within the normal range for human mandible cortical bone thickness. In addition, the artificial bone samples that were used in this study had an inferior alveolar nerve that ran through the bone structure, which is in line with the actual conditions that are found in actual clinical settings.

Conclusion

The accuracy of the augmented reality-based dynamic navigation system for placing dental implants in coronal and apical points was comparable to that of the conventional dynamic navigation system; however, the augmented reality-based dynamic navigation system produced a greater angular deviation.

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None

Conflict of Interest

None

References

1. Coelho PG, Marin C, Teixeira HS, Campos FE, Gomes JB, et al. (2013) Biomechanical evaluation of undersized drilling on implant biomechanical stability at early implantation times. J Oral Maxillofac Surg 71: e69-75.
2. Campos FE, Gomes JB, Marin C, Teixeira HS, Suzuki M, et al. (2012) Effect of drilling dimension on implant placement torque and early osseointegration stages: an experimental study in dogs. J Oral Maxillofac Surg 70: e43-e50.
3. Tabassum A, Meijer GJ, Wolk JGC, Jansen JA (2010) Influence of surgical technique and surface roughness on the primary stability of an implant in artificial bone with different cortical thickness: a laboratory study. Clin Oral Implants Res 21: 213-20.
4. Hanawa T (2019) Titanium-Tissue Interface Reaction and Its Control With Surface Treatment. Front Bioeng Biotechnol 7: 170.
5. Piqué EJ, Anglada M, RobledSM, Castaño JG, Echeverría F, et al. (2015) Osseointegration improvement by plasma electrolytic oxidation of modified titanium alloys surfaces. J Mater Sci Mater Med 26: 72.
6. Pacheco KA (2019) Allergy to Surgical Implants. Clin Rev Allergy Immunol 56: 72-85.
7. Remes A, Williams DF (1992) Immune response in biocompatibility. Biomaterials 13: 731-743.
8. Poli PP, Miranda FVD, Polo TOB, Júnior JFS, Neto TJL, et al. (2021) Titanium Allergy Caused by Dental Implants: A Systematic Literature Review and Case Report. Materials (Basel) 14: 5239.
9. Kumar PS (2019) Systemic Risk Factors for the Development of Periimplant Diseases. Implant Dent 28: 115-119.
10. Sakka S, Baroudi K, Nassani MZ (2012) Factors associated with early and late failure of dental implants. J Investig Clin Dent 3: 258-261.
11. Ostman PO, Wennerberg A, Albrektsson T (2010) Immediate occlusal loading of NanoTite PREVAIL implants: a prospective 1-year clinical and radiographic study. Clin Implant Dent Relat Res 12: 39-47.
12. Tomasi C, Derks J (2022) Etiology, occurrence, and consequences of implant loss. Periodontol 88: 13-35.
13. Erlebacher A (2013) Immunology of the maternal-fetal interface. Annu Rev Immunol 31: 387-411.
14. Guo T, Gulati K, Arora H, Han P, Fournier B, et al. (2021) Orchestrating soft tissue integration at the transmucosal region of titanium implants. Acta Biomater 124: 33-49.
15. Mayfield LJH, Mombelli A (2014) The therapy of peri-implantitis: a systematic review. Int J Oral Maxillofac Implants 29: 325-345.