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RESEARCH ARTICLE

Effectiveness of Prosthodontic Rehabilitation of Patients with Dental Defects and Severe Jaw Atrophy Using Short Implants:Narrative Review

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Abstract

Background: Scientific articles published in modern professional scientific literature do not sufficiently disclose the effectiveness and predictability of using short implants in the long term (more than five years) depending on biological, technical and biomechanical factors, which determines certain limitations in the use of short implants in clinical practice.

Objective: Based on a literature review, to evaluate the effectiveness of prosthodontic rehabilitation of patients with dental defects and severe jaw atrophy using short implants.

Methods: This literature review includes studies in which prosthetics of patients with various types of adentia and severe jaw atrophy was performed using short dental implants. The review included articles from Google Scholar, Medline, Scopus, Web Of Sciences, and PubMed. Search keywords terms included: severe jaw atrophy, bone augmentation, short dental implants, prosthodontic rehabilitation. Review was conducted according to the PRISMA guidelines.

Results: Conducted a preliminary search and reviewed 186 titles and abstracts in this review and 115 full-text articles were selected of high methodological quality. A review of the literature showed that researchers have different approaches to the use of short implants. A number of scientific studies report that short implants lead to a higher incidence of peri-implant bone resorption, implant-related complications, and prosthesis failures compared to standard implants. Therefore, it is recommended to use short implants (5–6 mm) with caution. Some researchers consider short implants as an alternative to increasing vertical bone height, noting the high clinical effectiveness of using short implants in orthopedic rehabilitation of patients with atrophy.

Conclusion: The current systematic review has shown the advantages of short implants are that their use allows to reduce the number of complex and expensive bone graft procedures to create a sufficient volume of bone tissue for implant placement, prevent damage to anatomical structures, reduce the time and cost of treatment. Optimization of short implants surface allows to increase the effectiveness of treatment, ensuring a long-term stable clinical results.

Keywords: Severe Jaw Atrophy, Bone Augmentation, Short Dental Implants, Prosthodontic Rehabilitation.

1. Introduction

The World Health Organization (WHO) considers complete or partial loss of teeth disability due to loss of chewing ability. Moreover, the loss of teeth significantly affects not only chewing, but also digestion, appearance and speech. Some patients develop bite anomalies, leading to impaired function of the maxillary joints [1]. Prolonged dentition inevitably

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leads to loss of volume of the jaw bone, which also causes aesthetic problems in patients, causing facial asymmetry, which, in turn, leads to social and psychological problems.

Studies have shown that 6 months after tooth extraction, the horizontal loss of bone tissue of the dental arch is 29-63%, and the vertical loss is 11-22%[2,3].

Tooth loss can cause chewing difficulties, which can affect dietary choices and food intake and cause digestive disorders, and therefore have consequences for overall health [3,4]. Furthermore, complete tooth loss has a major impact not only on chewing, appearance, and speech, but can also cause socio-psychological problems and affect the individual's social adaptation in society. Long-term, unrepaired edentulism can lead to temporomandibular joint dysfunction, jaw bone loss, and aesthetic problems in some patients, causing facial asymmetry [5-8].

Prosthodontic rehabilitation to restore the function of the dentition, helps to normalize the functioning of the digestive system and completely eliminate aesthetic defects, and improves the patient's quality of life.

It should be emphasized that patients with alveolar ridge develop complex clinical conditions for rational orthopedic treatment. The effectiveness of treatment with removable plate prostheses due to pronounced alveolar ridge in this group of patients is low, which leads to insufficient fixation of the prosthesis. Therefore, there is a need to develop an effective program of complex treatment and rehabilitation for this group of patients[9,10].

Of the modern methods of orthopedic treatment of patients with various adentia of the jaws, the method of orthopedic restoration using dental implants is currently widely used in clinical practice. The introduction of dental implantation methods in dentistry makes it possible to create optimal conditions for further effective rehabilitation in the dentofacial system of this group of patients [11].

As a result of the use of implants, jaw atrophy is sharply slowed down, reaching a physiological level, which undoubtedly plays an important role in maintaining the overall proportions of the face and, accordingly, the aesthetic appearance.

It should be noted that one of the most important prerequisites for effective prosthetics using dental implants is sufficient qualitative and quantitative characteristics of the jawbone for the preservation and stability of the implants, as well as obtaining predictable treatment results[12].

The main methods of dental implantation are designed for standard anatomical conditions, in which there is sufficient height and thickness for implant placement. In approximately 30% of clinical cases, due to unfavorable anatomical conditions, standard length implants are used only after bone-reconstructive surgeries that improve the quantitative parameters of the jawbone.

Over the past decades, the development and progress of dental materials and bioengineering have led to a decrease in standard diameters and lengths of implants and, consequently, increased the possibility of replacing missing teeth in patients with significant bone loss.

Various strategies of effective orthopedic treatment can be used. Conceptually, these strategies presuppose a choice of one of two paths. either an increase in the volume of bone tissue of the alveolar process, or the use of the residual volume of bone tissue in it with a narrower contour, or the use of short implants.

The first concept: methods of bone-restorative surgery are aimed at restoring the optimal anatomy of bone tissue and creating the possibility of installing implants of standard length and diameter due to a sufficient increase in the volume of bone tissue. Methods of bone-reconstructive surgery, which are currently used in the arsenal of maxillofacial surgery, allow to restore the integrity of the lost volume and the regenerative capabilities of the bone tissue of the jaw.

Different methods are used to increase the volume of bone tissue[13-20]. Increasing the volume of bone tissue of the alveolar process with the help of bone substitutes and membranes.

- Using autogenous bone.
- Sinus-lifting.
- Transposition of the inferior alveolar nerve.
- Sandwich plastic.
- Technique of splitting the narrow alveolar process.
- Distraction osteogenesis.

The choice of the method of bone-reconstructive surgery is determined by the localization of the defect, the amount of available jaw bone and soft tissues, as well as the general state of the patient's health.

These conditions of a favorable prognosis of bone-restorative operations are not always present in one and the same patient, and the favorable prognosis still remains controversial. It is also important to note that these operations require a high level of surgical skill, precise surgical technique, long recovery period, high risk of complications and expensive treatment[21-24].

The second concept use of shorts implants. In recent years, doctors seeking more conservative alternatives have tended to use short implants (5-6 mm) in patients with jaw atrophy [25- 28].

Currently, there is no clear concept of selecting individual restoration schemes for patients with complete dentition and significant atrophy of the jaw. Analysis of the literature indicates the need to evaluate the effectiveness of short implants in such patients over a long period of time, as well as to develop solutions that ensure their effectiveness. These questions are very relevant, they have both scientific and practical importance, which justifies the relevance and necessity of the conducted work.

2. Methodology

2.1 Comprehensive Search Strategy

Study selected if they met the following criteria: design - random allocation of participants.

The review included articles from Google Scholar, Medline, Scopus, Web of Sciences, and PubMed. Search keywords terms included: severe jaw atrophy, bone augmentation, short dental implants, prosthodontic rehabilitation.

The review was conducted according to the PRISMA guidelines (PRISMA flow chart is presented in figure1.).

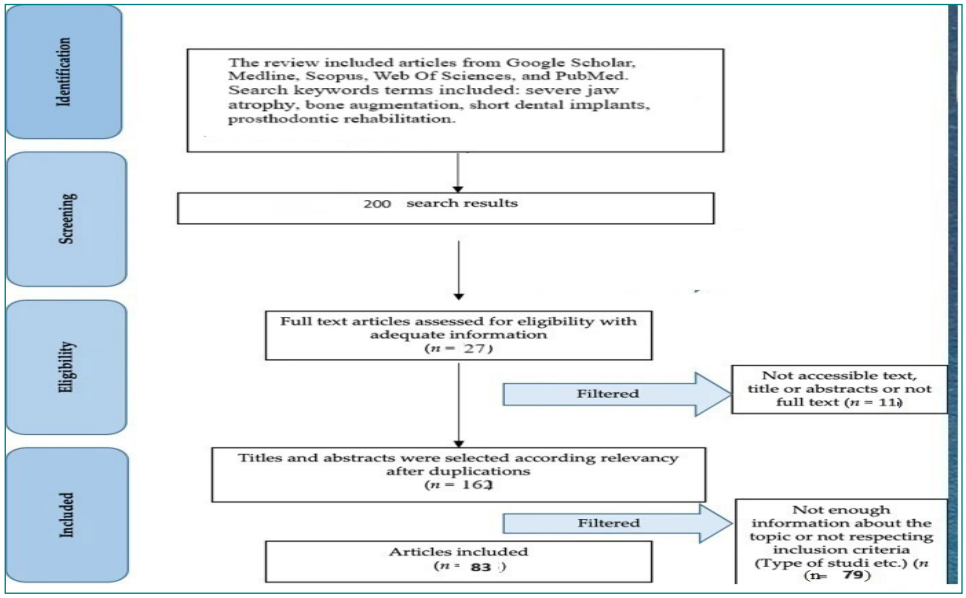

Figure1. *PRISMA flow chart is presented in*

2.2 Study Selection

2 independent reviewers (NG & GH) screened titles and abstracts for each study to determine eligibility following the predetermined inclusion and exclusion criteria. Potentially eligible studies underwent a full-text review, and discrepancies between reviewers were resolved through discussion. First, articles obtained from the database search were identified; then, articles were selected, excluding duplicates and those not relevant to certain descriptors, by screening titles and abstracts; after this step, an eligibility check was performed with full text reading, excluding articles that did not meet the previously established criteria; finally, relevant articles were included in the review. Inclusion criteria:Included clinical trials, considered randomized controlled trials, cross-sectional studies, case-control studies, and cohort studies in human subjects that evaluated the current literature short implants . There was no limitation on minimal quality, minimal sample size, or the number of patients.

Exclusion criteria: unpublished studies, conference abstracts, letters to the editor, case reports, in vitro and in vivo animal experimental studies to reduce publication bias. The effectiveness was evaluated by synthesizing relevant outcome data extracted from selected studies.

2.3 Data Extraction

Two reviewers extracted data from the included studies using a standardized data extraction form. Reviewers identify and document the threats to the validity of each study due to faulty execution or poor

measurement. Discrepancies in data extraction were resolved by discussion.

2.4 Quality Assessment

The effectiveness was evaluated by synthesizing relevant outcome data extracted from selected studies.

2.5 Data Synthesis and Analysis

The results of this review were reported following the PRISMA guidelines. A narrative synthesis of the findings was provided. Two independent reviewers reviewed the texts, selecting texts that met the inclusion criteria. The year of publication, study methodology, population (number of patients, mean age of patients), study results, outcome.

2.6. Effect Measures

The effectiveness was evaluated by synthesizing relevant outcome data extracted from selected studies. The outcome was to systematize information on the effectiveness of prosthodontic rehabilitation of patients with dental defects and severe jaw atrophy using short implants.

2.7. Risk of Bias

The form collects information needed to monitor the status of screening, reviewing and summarizing each article by 2 reviewers.

Developing tables that summarize the body of evidence.

The form captures detailed descriptive data about the intervention and evaluation.Classifying other key characteristics of the intervention and assessing the quality of the study's execution.

Reviewers identify and document the threats to the validity of each study due to faulty execution or poor measurement. This information is used as a criterion for continued inclusion of the study in the body of evidence for intervention.

Following the study design, it has identified domains rating the certainty of evidence: risk of bias, inconsistency and publication bias.

To assess the risk of bias, each individual criterion was considered to have a low risk of bias, a high risk of bias, or an uncertain risk of bias (lack of information or uncertainty related to potential bias). Discrepancies between authors were resolved by consensus.

2.8 Clinical Outcome

In the literature review, information of the effectiveness of prosthodontic rehabilitation of patients with dental defects and severe jaw atrophy using short implants.

3. Results of the Search

Conducted a preliminary search and reviewed 156 titles and abstracts in this review and 69 full-text articles were selected of high methodological quality.

This literature review includes studies in which prosthetics of patients with various types of adentia and severe jaw atrophy was performed using short dental implants.

Autologous bone grafts are considered the gold standard among bone substitute materials for the restoration of bone defects, as they contain viable osteoblasts and possess osteoinductive and osteoconductive properties[30]. In dental implantology, autologous intraoral grafts from the donor areas of the chin, branch of the lower jaw and alveolar process of the upper jaw are most often used. Intraoral autografts are structurally similar to the bone tissue of the recipient area, which causes their less resorption, faster vascularization and regeneration compared to intraoral autografts [31-33].

Despite the many advantages of vertical augmentation using autogenous bone blocks, the long recovery period, high risk of surgical complications, high cost of treatment, and increased patient morbidity associated with this type of procedure limit the use of this method [34-38].

When there is insufficient volume of bone tissue under the floor of the maxillary sinus, surgical sinus-lifting is considered optimal 26-29. A number of studies have described various bone materials for this operation: autologous bone taken from the crest of the lower jaw and intraoral area, allogeneic bone graft, xenogenic bone materials, bone substitutes – hydroxyapatite[39-40]. Systematic studies have shown that when using implants, the overall survival rate after sinus lifting is more than 90% [41].

Despite successful results, complications associated with maxillary sinus augmentation, such as membrane perforation, bleeding, and infection, as well as long healing periods necessary to achieve an adequate level of new bone formation, represent disadvantages for both physicians and patients [42].

In cases of pronounced atrophy in the masticatory region of the mandible, inferior nerve transposition is one of the implant treatment methods that has been used for the last twenty years, that postoperative

traumatic neuropathies have been recorded in patients after nerve transposition[43,44].

The use of the distraction method in reconstructive surgery of the jawbone requires careful planning and high technical training, which makes the widespread use of this method difficult [45]. This technique has the advantages of providing superior amount of bone lengthening thus eliminating the need of autogenous graft and donor site morbidity[46-49].

Some researchers believe that it is necessary to move away from additional surgical interventions and minimize invasive manipulations to increase bone volume. At the same time, the problem of choosing the optimal implant design for operation in conditions of bone tissue atrophy remains completely unresolved.

One of the options for solving the problem of dental implantation in conditions of bone tissue atrophy is the development of new implant designs that have sufficient biomechanical stability and durability, which will increase the potential for implantation in conditions of bone tissue atrophy. In this regard, minimally invasive implant technologies have become widespread - short implants without bone grafting, which can reduce the volume of surgery and the risk of complications.

In recent years, doctors seeking more conservative alternatives have tended to use short implants in the alveolar ridge.

According to a review of the scientific literature, the use of short implants leads to predictable results in terms of implant effectiveness, and according to recent clinical studies comparing the use of different sizes of implants, the use of short implants has a number of advantages for patients and physicians [50,51].

The current literature is still controversial, and published reviews do not sufficiently reveal the success/survival ratio of short implants due to inconsistencies between the reviewed studies and the differences in the available data. Systematic review methods are chosen to minimize bias, thus providing more reliable results[52,53]. Literature analysis shows that the height ratio of the implant to the orthodontic structure supported on it (C/I) can be a risk factor in terms of biomechanical stress distribution, since the use of short implants can increase the risk of complications associated with overloading. In particular, in the case of short implants, increasing the crown height creates an unfavorable crown-to-implant (C/I) ratio, since the lever arm increases and non-axial forces are generated, an increase in stress occurs in the palatal bone. Due to this, the C/I ratio was initially considered to be 1:1, as in natural teeth. However, some authors suggest the possibility of using a C/I ratio greater than 1:1, stating that the C/I index does not affect the effectiveness of orthopedic treatment with short implants [54-57].

According to published literature, short implant failures are due to a number of factors; the limited surface area of short implants may pose a potential risk to their long-term clinical performance, as they are less resistant to masticatory forces [58-59]. Therefore, the macro- and micro-design of short implants, including the surface area, should be optimized to improve their performance and ensure long-term stability.

In addition to increasing the surface area, increasing the number of implants and incorporating them into the same orthopedic construct can also balance the masticatory pressure, preventing implant stress.

According to these publications, the failures are due to a number of factors, the limited surface area of short implants may pose a potential risk to their long-term clinical performance, as they have less resistance to masticatory forces. Therefore, the macro and micro design and surface of short implants should be optimized to improve their performance and ensure long-term stability. In addition to increasing the diameter and surface area of the implant, increasing the number of implants and including them in the same orthopedic construction can also balance the masticatory pressure, preventing implant stress.

The fact that modification of the implant surface can affect the success of osseointegration has been demonstrated in various studies. This can be achieved by either subtractive processes on the implant surface, such as oxidation, or additive processes, such as the formation of micropores on the implant surface by plasma deposition of titanium powder, hydroxyapatite and calcium phosphate etching, surface acid treatment (SLA), as well as ion deposition [60-63]. All of the above methods lead to an increase in the implant surface area, while at the same time contributing to the improvement of the hydrophilicity of the surface. Currently, surface acid treatment (SLA) of implants is the most widely used technique.

Ultraviolet radiation has been used for many years in industrial and medical technology for the disinfection

of various surfaces. Human visible light has Wavelength range 400–700 nm. Ultraviolet radiation is classified according to wavelength (10–400 nm) as UVA (320–400 nm), UVB (290–320 nm), and UVC (10–290 nm). Ultraviolet radiation acts mainly photochemically. The range used in biological research is usually 200–400 nm, which includes all wavelengths: UVA, UVB, and some UVC [64-67].

Recently, the photocatalytic activity of titanium induced by ultraviolet light, including the formation of superhydrophilicity, has attracted widespread interest in implantology. The TiO surface of the implant is capable of integrating into bone. The surface layer of titanium is converted to titanium dioxide (TiO2) immediately after exposure to oxygen or atmospheric air. However, TiO2 in manufactured implants may lose its ability to bioactively integrate into bone after storage periods of less than 2 weeks, during which time bioactivity degradation occurs. The bioactivity of the implant surface can be restored by exposure to UV radiation. The biological effects of UV radiation on implant surfaces are defined as photofunctionalization, which is a simple and effective method to promote osseointegration. This process restores the biological reactivity of titanium implants that has been lost during manufacturing and storage in air, improving the osseointegration properties of the implant surface. UV radiation transforms the natural hydrophobic properties of Ti surfaces into superhydrophilic ones. UV radiation exposure generates surface energy on the TiO2 of the implant surface, which converts water into hydroxyl radicals: hydrogen and oxygen. Scientific research data have shown that UV light pretreatment of titanium significantly increases its osteoconductivity due to the UV catalytic progressive removal of hydrocarbons from the TiO2 surface, which implies photofunctionalization of titanium, allowing for faster and more complete bone-titanium integration [88-95]. UV radiation causes the formation of an electrostatic state on titanium surfaces, transforming the surface from hydrophobic to superhydrophilic, activating protein adsorption, and improving the activity of fibroblasts and osteoblasts. Hydrophilicity can enhance the initial attachment of osteoblast cells to the implant surface [68].

UV photofunctionalization has been proven to be an adjunct in improving the stability of implants. Studies have shown that UV photofunctionalization can accelerate the osseointegration process and achieve earlier solid fusion between the implant and the surrounding bone. It has been found that UV light treatment of the implant surface promotes a 3-fold increase in implant osseointegration [69,73].

It is known that UV radiation also has an antimicrobial effect through photochemical reactions, affecting the DNA of bacteria. Irradiation of titanium surfaces with UV light has shown an antimicrobial effect due to enhanced photocatalytic properties, suppressing periodontal pathogenic bacteria. UV radiation reduces the adhesion of bacteria to the surface of TiO implants and can enhance the attachment of epithelial cells to TiO [74]. Photofunctionalization of implants is currently also used in the complex of prevention and treatment of peri-implantitis[75-79].

4. Disscusion

Despite the existing publications on the progress of dental implantology, the problem of prostethetic rehabilitation of patients with various edentia and pronounced atrophy of dental protrusions remains relevant.

Scientific articles published in the current professional scientific literature do not sufficiently reveal the effectiveness and predictability of the use of short implants in the long term, depending on biological, technical and biomechanical factors. Currently, there is no clear concept for the selection of individual restorative schemes for patients with edentulism and significant jaw atrophy.

In study Marco Esposito et al (2019) was to compare the clinical efficacy of 4- to 6.6-mm long implants and 11- to 13-mm long, 4-mm diameter implant-supported orthodontic structures in patients with mandibular atrophy after vertical augmentation with bone blocks in the segment of mandibular atrophy[80]. The treatment outcomes of 135 patients were analyzed five years after prosthetics.

The following indicators were included in the assessment of the effectiveness of the treatment:

- Early biological complication - implant disintegration.
- Any complication during implant placement or at the site of the autologous bone donor (e.g., infection, nerve injury, bleeding).
- Failure of vertical bone augmentation of the dental abutment, when the graft did not provide sufficient

bone volume to accommodate the planned long implants.

- Implant loss.
- The height of peri-implant bone loss, estimated by technology on periapical radiographs in mm.
- Peri-implantitis with changes in the level of the marginal bone.
- Mechanical complications (e.g., implant fracture or deformation of the implant-abutment connection).
- Loosening or fractures of the screw fixing the prosthesis.

In twelve (14%) patients, bone augmentation surgery did not result in the planned bone height that would allow the placement of implants of the planned length. After five years of loading, 28 patients (21%) were lost to follow-up and the results of the study of these patients were not included in the overall results.

According to the results of the authors' study, the loss of prostheses and implants after 5 years of prosthetics was short The same complication rates were recorded for implants placed longer than 10 mm after vertical bone augmentation and implants placed longer than 10 mm after vertical bone augmentation, but the loss of peri-implant marginal bone was greater in implants placed longer than 10 mm in the vertical bone augmentation segment. According to the authors, short implants may be the preferred option in such clinical cases, while noting that longer-term follow-up may provide more reliable results.

The analysis of the literature indicates that there is a need to evaluate the effect of the length, diameter and C/I ratio of short implants in such patients in terms of biological complications, as well as their effectiveness in the long term.

Tang Y et al 2020 in study aimed to evaluate the clinical effectiveness of short implants (8 mm in length and 5 mm in diameter) in relation to the crown-to-implant ratio (C/I) as well as the influence of other patient and prosthesis-related factors on the functional performance of short implants [81]. The study included 130 patients with partial edentulism and pronounced alveolar ridge, in whom 180 short implants were placed, dynamic control was carried out after 3 to 7 years of functional loading (mean, 4.2). Potential risk factors were assessed (patient gender and age, implant diameter and location, built-up and single-tooth restorations, anatomical and clinical C/I ratios). The following indicators were included in the assessment of effectiveness: implant osseointegration, three-implant cataract bone loss (MBL), mechanical and biological complications.

5. Results

A total of 4 implants in 4 patients disintegrated due to peri-implantitis. The mean peri-implant marginal bone loss (MBL) in the 180 short implants was 0.90±0.78 mm. The mean clinical C/I ratio was 1.16±0.36. Correlation analysis showed that the effect of clinical C/I ratio and patient age was significant for bone loss (MBL), while other potential risk factors did not show a significant association with the outcome. Among the 180 short implants: 24 cases (13.3%) had biological complications and 32 cases (17.8%) had mechanical complications. There were no statistically significant differences in the incidence of bone loss (MBL) and complications between single-contour and single-contour crowns. The results showed a 97.8% survival rate for short implants after a follow-up of approximately 3 to 7 years, which is consistent with previous studies. From these studies, the authors concluded that fixed prostheses placed on short implants in the posterior region of the maxilla with apical abutments showed predictable clinical outcomes over a 3- to 7-year period. In the range of 0.47 to 3.01, the higher the C/I ratio, the less bone loss (MBL). Other investigators have not found a significant relationship between the C/I ratio of the implant and the C/I ratio of the crown height[40].

Study Eduardo Anitua et al (2022) aimed to evaluate the effectiveness of fixed orthopedic restorations on short (≤8 mm) and narrow diameter (≤3.5 mm) implants in patients with edentulous patients and pronounced alveolar bone loss[82]. The control group included patients who received long and narrow implants (length > 8 mm and diameter ≤ 3.5 mm). During the study, the effectiveness of implants and peri-implant bone loss were evaluated and statistically analyzed. 41 implants were placed (18 and 23 implants in the main and control groups, respectively). The average follow-up period after implant placement in both groups was 26 months. The results showed that there were no significant differences in implant loss and peri-implant bone loss. In the short implant group, There was only one case of screw loosening. It was concluded that short and small diameter implants may be an alternative for the restoration of severely overgrown jaws.

Dr. Faraaz M. en al 2021; The in vivo study aimed to evaluate the success rate of osseointegration of short implants photofunctionalized with UV light and standard length implants without prior photofunctionalization [114]. The study included 20 patients over 18 years of age (10 males 50% and 10 females 50%). 10 implants were placed in the maxilla, 8 implants were placed in the anterior mandible, and 12 implants were placed in the posterior mandible. The patients were divided into two groups: The control group received standard length implants without prior photo functionalization. The main group received short implants photo functionalized using ultraviolet light.

The quality of a dental implant depends on the surface properties and affects the mechanical strength between the implant and the tissue. In addition, the surface coating contributes to the osseointegration of the implant into the bone tissue. The fact that the modification of the implant surface can affect the success of osseointegration has been proven in various studies. The macro- and micro-design of short implants should be optimized to improve their success rate and long-term stability (primary stability immediately after implant placement, secondary stability after osseointegration, tertiary stability under loading conditions). Elderly patients with common comorbidities and concomitant medications will benefit from these innovations.

The analysis of the presented problems, as well as the need to solve them, substantiates the relevance of the present work. The current systematic review has shown the advantages of short implants are that their use allows to reduce the number of complex and expensive bone graft procedures to create a sufficient volume of bone tissue for implant placement, prevent damage to anatomical structures, reduce the time and cost of treatment. Optimization of short implants surface allows to increase the effectiveness of treatment, ensuring a long-term stable clinical results.

Declaration

Conflict of interest

The author declares that he has no Conflict of interest. None of the authors have relevant financial relations with a commercial interest.

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Ethical Approval

“Not applicable”

Consent for publication

“Not applicable”

Availability of data and materials

“Not applicable”

Permission to reproduce material from other sources (if needed)

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