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Efficiency of Implant-Prosthetic Rehabilitation in Patients with Short Implants Placed in Atrophic Posterior Mandible, 5 Years Results of a Prospective Single-Center Study

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Abstract

Objective: The aim of this study is to evaluate survival and complications associated with short implants (6 <8 mm) in the rehabilitation of patients with atrophic ridges of the mandible. ***Materials and Methods:*** We performed a prospective study in 78 patients (32 women and 46 men, age: 54.6 years, range 38–63) participated with atrophied mandibles with 702 short implants (Bicon, LLC, USA).104 implants were 5.0mm long, 485 implants were 6.0mm long, and 123 implants were 8.0mm long, diameters implants from 3.0mm to 6mm) All patients underwent a thorough clinical examination according to the generally accepted scheme. The study included patients in whom the location of the inferior alveolar canal from the crest was 6–9mm, width ≥5 mm (as determined radiographically). All patients were selected after meticulous evaluation of their medical histories and dental examinations, including dental cone beam CT scans. Of the total number of patients (78), 27 patients were edentulous, 51 patients were partially edentulous. 27 edentulous patients, implants were inserted using surgical guides. All implants were installed with a conventional surgical protocol. Postoperative therapy included antibacterial, anti-inflammatory drugs. Implantation was carried out according to a standard two-stage protocol developed by the manufacturer. The 3 months later after in second stage implantation, the method of RFA-Resonance Frequency Analysis method was used. The functional load on dental implants was performed with ISQ values above >65. The prosthodontic rehabilitation was carried with implant supported non-removable orthopedic structures. The following parameters were recorded and evaluated: implant survival, MBL over time. The marginal bone lose MBL of the jaw around the implant was also 3 months after loading the prosthesis; and 1 year, 2 years, 3 years and 5 years after implant placement. ***Results:*** We analyzed data from 76 patients who were assigned to 702 implants (in the mandible). No postoperative complications were reported. All patients had healthy soft tissues. The mean implant stability index (ISQ) was 69.2±10.6 for primary stability at implants placement, respectively 73, 6 ISQ after 3 months befor loading. Compared to baseline, mean marginal bone loss (MBL) after 6 months of prosthetic loading was 0.51±0.28, at the end of the 1 year 0.94±0.31, at the end of the 3 year 1.23±0.34 respectively, at the end of the 5 year 1.45±0.61. On average, over the observation period (42.6 ± 16.4 months), the implantation success rate was 96.8% in the lower jaw (two implants were lost), and the prosthetics success rate was 98.7%.The results obtained are comparable with success criteria in implant rehabilitation. The reported technique proved to be successful in the population observed, with minimal trauma and reduced invasiveness. The patients were satisfied with the aesthetic and functional result of the treatment. ***Conclusion:*** In patients with mandible bone atrophy, short implants with an optimized macrostructure represent a reliable method of functional rehabilitation. The results showed that short implants with is effective in improving the chewing ability of the patients with an atrophied mandible.

Keywords: Short dental implants, bone augmentation, prosthodontic rehabilitation.

INTRODUCTION

Implant-prosthetic rehabilitation is a modern practice in clinical dentistry and is characterized by safe and predictable results in the long term [1, 2].

The prosthetic rehabilitation in atrophic posterior mandibla is a current topic in implant dentistry. Adequate residual bone volume is essential for the retention and stability of the implants and to achieve favorable results [2, 3].

Bone resorption after tooth extraction can be a serious problem in orla implantology and restorative dentistry. When a tooth is removed, bleeding occurs, followed by the formation of a blood clot that fills the entire hole. Over the next 2-3 weeks (3-4 weeks after removal), it begins to mineralize from the base of the socket in the coronal direction. This is followed by ongoing re-epithelialization that completely covers the well six weeks after removal. Further bone filling occurs with maximum radiographic density after about 100 days. During the first year after tooth extraction, the loss of alveolar bone occurs at a rapid rate and can last for years. Vertical ridge bone resorption reaching 1.4 ± 1.94 mm after 8 weeks, and during the first three months, the decrease in the width of the horizontal ridge is approximately 50% After tooth loss, within 1 year, the width of the crest bone decreases by 25%, and after the first 1-3 years, the width of the bone decreases by 40%, which leads to atrophy of the jawbone, which complicates the optimal aesthetics of implantation and long-term results [4-6]. If there is no treatment to restore the dentition, bone loss continues and up to 40–60% of the ridge volume is lost in the first 3 years [7, 8]. Alveolar bone loss is a common finding associated with periodontitis.

In many cases, dental implants can be placed without any obstruction; however, in some cases, adverse local conditions such as jaw atrophy, bone defects due to periodontitis, and the sequelae of trauma may result in insufficient bone volume for implant placement due to defects in one or more dimensions. These situations are also associated with the proximity of anatomical structures, such as the inferior alveolar nerve, the maxillary sinus floor or the fundus of the nose, which complicates the possibility of adequate or incorrect from a functional and aesthetic point of view of implant therapy.

Rehabilitation of atrophied alveolar ridges remains a challenge in implant dentistry [9-11]. Using the longest implants has always been an important consideration as it allows for optimal primary stability and a large bone contact area, factors that are considered the key to success [12-14].

Various surgical procedures for the rehabilitation of patients with an atrophic mandible have been described in the literature, including overhead grafts and various types of osteotomies. Conceptually, these strategies follow one of two paths: either augmenting the bone or reusing the remaining bone. Recently, a combination of augmentation and dental implantation has been used to treat cases of severe bone atrophy of the upper and lower jaw. The widely used methods of increasing the volume of bone tissue in defective areas have been described: directed bone regeneration, autogenous bone graft, sinus lifting, and lateralization of the alveolar nerve, alveolar distraction osteogenesis and reconstruction of vascularized bone with a free flap [15-22].

The intraoral bone can be taken from the upper and lower jaw, including the mandibular symphysis, mandibular ramus. Intraoral bone blocks have a low rate of resorption, but they are not always available and sometimes do not have sufficient volume for transplantation [23, 24]. In cases with large bone defects, extraoral donor sites are required. Extraoral donor bone can be obtained from the iliac crest, cranial vault, or tibia [25-27]. Other graft materials used in clinical practice are cattle derived xenograft substitutes, allograft bone, and artificial bone such as bioglass, hydroxyapatite or calcium phosphate [28-31]. For the reconstruction of large bone defects, autologous or homologous bone grafts in the form of blocks are preferred in order to restore the correct vertical and/or horizontal dimensions. However, doctors and patients are very cautious about such reconstructive methods. This is largely because, therefore, the driving force behind research teams now is the reduction in morbidity associated with dentoalveolar and cranio-maxillofacial bone reconstruction and the ultimate goal of helping patients to better perceive and use such methods. These surgical procedures provide increased treatment time, morbidity and cost for patients [32]. In this particular clinical situation, short implants are shown. In this context, short implants of less than 8 mm length customize the treatment option for this type of patient, as they can avoid increased financial costs, treatment time and patient morbidity and are a viable alternative treatment.In cases of atrophied alveolar ridge, short dental implants (SDI) can be used [33, 34].

Accordingly, in clinical situations with little bone accessibility, short implants are a viable, simple and predictable alternative. Short implants represent a simple surgical technique compared to bone repair surgeries used to fix standard implants, reducing treatment time and morbidity [35].

Lack of implant crown ratio can result in poor biomechanics resulting in peri-implant bone loss, leading to premature implant loss. However, Anitua in a retrospective study conducted at the Edward Anitua

Institute between 2001 and 2009 using 128 ultrashort short implants (5.5 mm to 8.5 mm) measured the change in the bone ridge and concluded that there was no significant association between bone loss ratio and crown implant short and ultrashort implants [36]. Biomechanical aspects and loss of marginal bone in short implants compared to conventional implants, studies show that there was no significant difference over a period of 2 to 3 years. However, there are no long-term clinical studies. The survival rate of short and ultrashort implants does not depend on the implant diameter and the ratio of the implant crown [37-42].

Short dental implants are an alternative treatment to bone grafting. What's more, shorter implants can give similar results to longer implants. Rehabilitation treatment with implants established new denture planning concepts, and this approach provided the patient with effective chewing function as well as established aesthetic alternatives.

Rieger *et al*. conducted a study using finite element analysis and reported that minimal stress is transmitted to the most apical part of short implants. Finite element analysis studies showed that the length of the implant did not significantly affect the distribution of tension, as the highest concentration is concentrated on the alveolar ridge surrounding the implants [43, 44].

This fact supports the use of shorter implants as it offers certain advantages in certain clinical situations [45]. Therefore, the use of short implants is justified by the fact that the bone/implant interface distributes most of the occlusal forces to the uppermost part of the implant body, close to the alveolar ridge, where the cortical bone is present at the level of the implant platform [46].

MATERIALS AND METHODS

We performed a prospective study in 78 patients (32 women and 46 men, age: 54.6 years, range 38–63) participated with atrophied mandibles with 702 short implants (146 were ultrashort and 556 short) from Bicon Dental Implants (Bicon, LLC, USA). Bicon implants – referred to as short or ultrashort – can be as short as 5.0 mm 8, 0. This allows the implants to be placed in regions that would otherwise require a bone graft.

The Bicon short implant system is a screwless implant system. The implant and implant-abutment unit connect with a 3° locking taper in a screwless system [47]. The high-friction force created by the locking taper breaks down the titanium oxide layer, and the metals become fused together in a cold weld. All patients underwent a thorough clinical examination according to the generally accepted scheme. The study included patients in whom the location of the inferior alveolar canal from the crest was 6–9mm, width ≥5 mm (as determined radiographically).All patients were selected after meticulous evaluation of their medical histories and dental examinations, including dental cone beam CT scans.

Of the total number of patients (78), 27 patients were edentulous, 51 patients were partially edentulous. 27 edentulous patients, implants were inserted using surgical guides.

All patients underwent a thorough clinical examination according to the generally accepted scheme. The study was designed as a prospective, single-center study that met the STROBE criteria (see Supplementary Materials). The study included patients. All patients underwent a thorough clinical examination according to the generally accepted scheme. After completing the diagnostic examination, a treatment plan using computed tomography was developed. The participants in this study were recruited during their implantology consultations. The study was designed as a prospective, single-center study that met the STROBE criteria (see Supplementary Materials). Patient demographic data (age, gender), systemic condition, concomitant diseases, concomitant medications were recorded, as well as dental status.

All procedures in this study were performed in accordance with the ethical standards of the institutional research committee (28/07/2018, registration number 2018-64) and with the 1964 Declaration of Helsinki and later amendments thereto. Informed consent was obtained from all individual participants included in the study.

Inclusion criteria

The study included patients in whom the location of the inferior alveolar canal from the crest was 6–9mm, width ≥5 mm (as determined radiographically).

Exclusion criterion

Exclusion criteria included any systemic condition that could interfere with physiological wound healing, orofacial cancer, radiation / chemotherapy to the head and neck area, untreated active periodontal disease, any sinus pathology, previous history of sinus surgery.

All patients were selected after meticulous evaluation of their medical histories and dental examinations, including dental cone beam CT scans. The initial height of the bone from the alveolar ridge t the width of the ridge of the edentulous area were measured using CT, the examination was done before surgery and 3 and 6 months after surgery, after prostetic loading (fig.1,2).

Outcome measurements included implant survival.

Mobility of previously clinically integrated osseointegrated implants or removal of fixed implants due to progressive loss of marginal peri-implant bone and infection was defined as implant loss:
The following criteria were also evaluated:
Primary stability of the implant
Radiographic loss of marginal bone around the implant

The 3 months later after in second stage implantation, the method of RFA-Resonance Frequency Resonance Frequency Analysis (RFA) (Osstell AB, Göteborg, Sweden) measured implant stability coefficient (ISQ) values using Smart Pegs. Implant stability was classified as low with ISQ values <60, moderate with ISQ values 60–70, and high with ISQ values> 70.The functional load on dental implants was performed with ISQ values above>65. The prosthodontic rehabilitation was carried with implant supported non-removable prosthetic structures 3 months after implant placement (fig 3).

The following parameters were recorded and evaluated: implant survival, MBL over time. The marginal bone lose MBL of the jaw around the implant was also 3 months after loading the prosthesis; and 1 year, 2 years, 3 years and 5 years after implant placement.

An X-ray was used to detect any bone abnormalities and assess the alveolar bone around each implant. The implant failure criteria were based on the ICOI Pisa Consensus Implant Quality Scale. An implant was considered unsuccessful (clinical or absolute ineffectiveness) if it had any of the following conditions: functional pain, mobility, radiographic bone loss> 1/2 of the implant length, uncontrolled exudate, or was no longer in the implant [47].

STATISTICAL ANALYSIS

Statistical analyzes were performed using SPSS (SPSS 25.0®; SPSS Software Company, Chicago, IL, USA). The p values <0.05 were considered statistically significant. Differences between observation periods were checked using the paired Student's t test.

RESULTS

We analyzed data from 76 patients who were assigned to 702 implants (in the mandible). No postoperative complications were reported. All patients had healthy soft tissues. The mean implant stability index (ISQ) was 69.2 ± 10.6 for primary stability at implants placement, respectively 73,6 ISQ after 3 months befor loading. Compared to baseline, mean marginal bone loss (MBL) after 6 months of prosthetic loading was 0.51±0.28, at the end of the 1 year 0.94±0.31, at the end of the 3 year 1.23±0.34 respectively, at the end of the 5 year 1.45±0.61 (table 1). 19 implants failed with a diagnosis of peri-implantitis, (6 implants after 2 years, 8, after 3 years and 4 implants after 5 years). On average, over the observation period (53.6 ± 16.4 months), the implantation success rate was 97.3%, and the prosthetics success rate was 98.7%. The results obtained are comparable with success criteria in implant rehabilitation. The reported technique proved to be successful in the population observed, with minimal trauma and reduced invasiveness. The patients were satisfied with the aesthetic and functional result of the treatment.

Table-1: MBL of each prosthesis group at prosthetic loading and 5years after implant installation

Time after implant placement and	MBL
6 months after of prosthetic loading	0.51±0.28
1years after prosthetic loading	0.94±0.31
3years after prosthetic loading	1.23±0.34
5 years after prosthetic loading	1.45±0.61

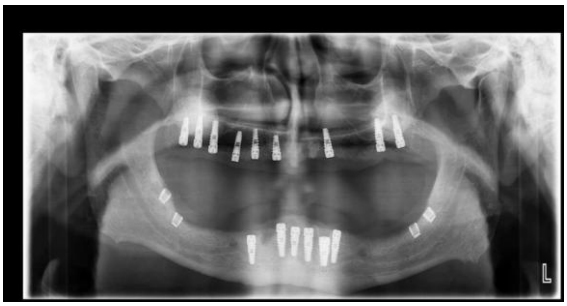

Fig-1: CT scan after implants insertion

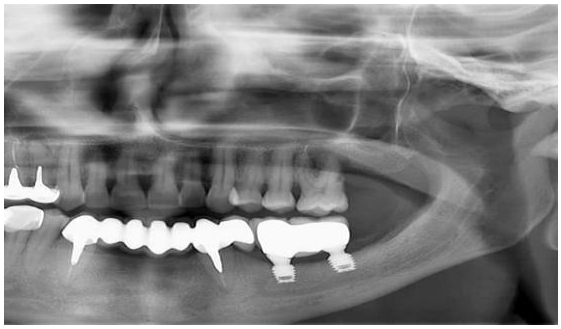

Fig-2: CT scan after prosthetic rehabilitation

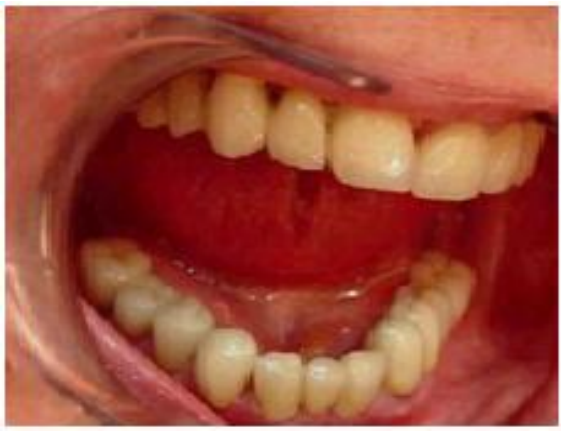

Fig-3: Intraoral view after prosthetic rehabilitation

DISCUSION

For effective implantation, the quantitative and qualitative parameters of the alveolar ridge of the jawbone are important, since in case of bone deficiency in the edentulous jaw, it is difficult to install implants longer than 10 mm [48]. Various methods of bone augmentation are used to restore the resorbed part of the alveolar crest of the bone after jaw bone grafting; however, the duration of the postoperative rehabilitation period and the risk of various complications limit the widespread use of various methods of treatment [49-55]. With the reduced height of the alveolar bone, short dental implants with improved designs and surfaces are available recently, which are offered to clinicians to facilitate prosthetics under anatomical constraints. For the rehabilitation of an atrophied jaw, short dental implants can be an alternative approach with fewer biological complications in bone augmentation. Short implants are mainly used to prevent bone augmentation surgeries in the posterior segments of the upper and lower jaw in partially edentulous patients.

According to the results of the last European Consensus Conference on Short Implants, Ultrashort Implants were defined as implants with - <6 mm in length, short implants ≤8 mm in length and ≥3.75 mm in diameter, standard implants as implants> 8 mm in length and ≥3.75 mm in diameter [56].

The use of short implants is indicated primarily to avoid bone augmentation procedures, and they are applicable if the vertical volume of the bone is limited to the maxillary sinus, the mandibular canal, but the width of the alveolar ridge is sufficient to use implants with a diameter of 3.75 mm [57]. They are also used to support removable dentures as replacements for one or more teeth in the anterior jaws.

Previously, short implants were considered to have lower survival rates and less long-term results compared to standard implants , now due to improved design, scientific evidence suggests that short implants (> 6 but ≤8 mm) have similar survival rates compared to standard implants (> 8 mm) [58, 59].

For short implants, there is currently insufficient data to make a recommendation. Long-term data over 10 years of observation of the posterior mandible of partially edentulous patients showed favorable results for short sintered implants with a porous surface[60]. Short implants should only be used if the bone quality is good.

A retrospective study Friberg B *et al.* in 49 patients with an edentulous mandible and bone resorption had an E shape and a Lekholm and Zarb quality 1. None of the 5 mm × 6 mm implants were lost, which is why the author recommends this treatment procedure for a highly resorbed mandible [61].

Installation at bone level or below with a tapered abutment. The implant surgeon and restoration dentist must have appropriate training. However, biomechanical factors associated with crown and implant wear may play a role in the long-term performance of the prosthetic structure.

The crown and implant (C/I) ratio is important for the prevention of complications, since the use of short implants can increase the risk of biomechanical complications due to overload / off-axis loading and, ultimately, can lead to loss of ridge bone [62-65].

However, several studies have reported that the C/I ratio does not affect the effectiveness of treatment with short implants and the length of the implants does not affect the loss of marginal bone [66, 67].

The increased crown-to-implant ratio (C/I) in short dental implants with favorable occlusal loading does not appear to cause peri-implant bone loss. A higher C/I ratio does not negatively impact implant success. For favorable occlusal loading, an increase in the crown to implant ratio (C/I) in short dental implants with does not appear to cause peri-implant bone loss, and it follows that a higher C/I ratio does not adversely affect implant success [68-70].

To achieve primary stability with short implants due to less bone-to-implant contact and reduced stress in posterior short implants, a short implant with a large diameter is used, which increases the bone-implant contact surface area, providing the patient with a mutually protected occlusion [71].

Literature reviews confirm the effectiveness of the use of short implants with a length of 6.0 mm and 8.0 mm with an innovative design and surface texture in orthopedic rehabilitation with resorption of the jaw ridge [72, 73].

The presented technique weth short implant may represent a viable alternative to traditional bone graft for atrophied edentulous posterior mandibula. Biomechanical studies show that wide diameters should be preferred when using short implants. Finite element analysis has shown that the stress values around the implant and the concentration area decrease for the cortical bone with increasing implant diameter [74].

Therefore, the macro- and microdesign of short dental implants should be optimized to improve their success and long-term stability (primary stability: ridge resorption patient populations can benefit from short implants, allowing graft-free rehabilitation and reducing invasiveness [75-75].

In this study, we set ourselves several goals. To assess whether short implants without augmentation can be considered a successful alternative treatment in the rehabilitation of posterior atrophic ridges. Research the clinical results of fixed prostheses supported by implants of 5 to 8 mm lengths instaled in vertically atrophic mandibles after 5 years of follow-up. Based on the work, it can be argued that the main indication of short implants is to avoid invasive surgical procedures such as bone grafts in atrophic areas. The stability of the marginal bone observed short implants in this study confirms the effectiveness of the use of short implants in the atrophied area of the edentulous jaw, which was previously confirmed in other studies [76].

The installation of short implants is proposed as an alternative method of treatment for orthopedic rehabilitation of partially edentulous atrophic lower jaw, in order to avoid additional surgical procedures and reduce postoperative complications.

Despite the limited sample size and storage time, short implants are predictable treatment options for patients with severe posterior mandibular atrophy. However, the results of the study must be validated on a larger sample size, as treatment outcome can be influenced by various anatomical, prosthetic, surgical and patient-related factors.

CONCLUSION

Short implants are a viable alternative to the treatment of ridges showing atrophy, demonstrating satisfactory survival and a low incidence of prosthetic and biological complications over a 5-year follow-up period. The splinting of short implants is associated with fewer orthopedic complications and less implant destruction.

Conflict of interest and financial disclosure

The author declares that he has no conflict of interest and there was no external source of funding for the present study. None of the authors have any relevant financial relationship(s) with a commercial interest.

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