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THE EFFECT OF LOW INTENSITY ULTRASOUND THERAPY ON OSSEOINTEGRATION OF TITANIUM DENTAL IMPLANT PLACED IN THE ESTHETIC ZONE

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ABSTRACT

Background: Endosseous dental implants may be considered as the most popular treatment option for partially and fully edentulous patients. It is generally accepted that implant success is primarily dependent upon or achieved by osseointegration, a direct contact between the implant surfaces and living bone and gum. For decrease the time of osseointegration there is a different modalities used as altering the surface and/or shape of the implant has been frequently researched and it has been shown that rough implant surfaces allow a higher percentage of bone-to-implant contact compared to implants with smooth surfaces. Also dual acid etching of titanium, engineering of dental pulp cells on various implant surfaces and biomimetic implant coatings containing bone morphogenetic protein-2._Other methods studied to enhance endogenous bone healing around biomaterials are different forms of biophysical stimulations such as pulsed electromagnetic fields and low intensity pulsed ultrasounds (LIPU). Ultrasound is a form of energy that is transmitted through biological tissues as high-frequency acoustic waves, which is widely used in medicine as a diagnostic, therapeutic and operative tool.

The aim of the present study was to evaluate The effect of low-intensity pulsed ultrasound on the osseointegration of titanium dental implants .

Patient and methods: Ten implants were placed in ten patients each one receives one implant. The patients were 6 males and 4 females ranged in ages from 25 to 40 years. All the implants were placed in maxilla. Observations were made postoperatively at time of implant placement then after one month, 3 months, 6 months and one year follow up periods for crestal bone loss and stability, Data analysis was performed in several steps. Initially, descriptive statistics for each case results. One way ANOVA followed by pair-wise Tukey post-hoc tests were performed to detect significance between preparation cases. Statistical analysis was performed using Graph-Pad Prism-4 statistics software for Windows. P values ≤0.05 are considered to be statistically significant in all tests.

Conclusion: From the a aforementioned review it became clear that Low-intensity pulsed ultrasound could be accelerate the osteointegration of dental implant .

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INTRODUCTION

Dental implants have a centuries-long history; indeed there is evidence that prehistoric peoples sought this technology. [11,12] As dentistry progressed in the past century, experimental implant designs focused on materials and techniques that might serve as quality anchorages for conventional dental prosthesis. By the mid-20th century, a number of sophisticated techniques had been developed, including subperiosteal, transosteal and blade implants. However none of these techniques were widely adopted because of high costs and unpredictability. Furthermore, although some of these implants functioned reasonably well for years, some began to show signs of failure shortly after insertion. [13] Patient often faced complex retrieval surgeries once these types of implants became intolerable.

Osseointegration refers to a direct bone-to-metal interface without interposition of non-bone tissue. This concept has been described by Branemark, as consisting of a highly differentiated tissue making “a direct structural and functional connection between ordered, living bone and soft tissues [14,15]. Through his initial observations on osseointegration, Branemark [14] showed that titanium implants could become permanently incorporated within bone that is, the living bone could become so fused with the titanium oxide layer of the implant that the two could not be separated without fracture. It occurred to this investigator that such integration of titanium screws and bone might be useful for supporting dental prostheses on a long-term basis.

The most important aspect of early peri implant healing is the recruitment of osteogenic cells and their migration to the implant surface([16]. So the term “osteoconduction” to encapsulate these important early events that will position the osteogenic cells on the surface of the implant where they can than make bone matrix. The *de novo* formation of bone itself can therefore be considered as a separate and distinct phenomenon which, in time, will be followed by the remodeling of the peri-implant bone.The combination of osteoconduction and bone formation will result in contact osteogenesis. The longterm remodeling of the tissue is influenced by different stimuli, the most important being the biomechanics of the developed healing site, and thus should also be treated separately. [16]

Ultrasound: What is it and what does it do?

A fundamental understanding of ultrasound (US) functionality is essential to understand its role in the physiology of fracture healing. Ultrasound is a modality that applies transcutaneous acoustic energy for diagnostic and therapeutic purposes. Sound waves produced by a piezoelectric crystal are transmitted through various body tissues to induce a number of physiologic changes implicated in tissue healing.[17,18] The proportion of sound waves absorbed by a specific tissue is directly related to that tissue’s density. Bone typically possesses the densest tissue in a given area, allowing for the use of US waves to effectively target areas where bony abnormalities may exist. [19]

LIPUS, in particular, serves as a potential noninvasive therapeutic toward fracture healing. [20] The waves administered by LIPUS induce micromechanical stress in the fracture site, culminating in the stimulation of various molecular and cellular responses involved in fracture healing. [21] The beneficial osteogenic and angiogenic effects observed after LIPUS administration are largely nonthermal (< 1°C), and rather mechanical in nature. The operating parameters used to achieve these benefits include a 30-mW/cm^2 intensity, 1.5-MHz frequency repeated at 1 kHz, and a pulse width of 200 μs administered for 20 minutes each day.[21,22]

LIPUS also causes increased expression of early osteogenic genes, including osteonectin, osteopontin, and insulin growth factor-1. These play a crucial role in ensuring proper osteoblast differentiation.[23,24] Osteoprogenitor cells from the bone marrow may also differentiate into osteoblasts at an increased rate by detecting the LIPUS-induced increase in local blood pressure via membranous integrin proteins.[25,26, ,27]

Aim of the study

The aim of the present study was to evaluate the effect of low-intensity pulsed ultrasound on the osseointegration of titanium dental implants .

PATIENTS AND METHODS

Ten Patients with tooth loss in aesthetic zone were selected from those who attended the outpatient clinics of Oral and Maxillofacial Surgery Department, Faculty of dental medicine of AL-Azhar University in Cairo (Boys) based on the following criteria: Criteria for the Selection of the Patients

Preoperative preparation:

All patient were prepared for surgery by the same protocol follow:

1. Clinical evaluation:

Intraoral and extra oral examinations were carried; hard and soft tissue structures were evaluated as to both quality and quantity.

Extra oral examination involved the presence or absence of any pain, TMJ disorders as sublaxation, dislocation and/or abnormal swellings.

Medical histories were detected for all patients and exclude some cases having patient with osseometabolic disorders e.g rhaumatoid arthritis, uncontrolled diabetes, liver and renal disorders, taking steroids or anti-cancer drugs and Patients with parafunctional habits as bruxism and clenching.

Preoperative photographs. (Fig.1)

Preoperative radiograph: periapical (PA.Film) using paralleling technique (Fig.2), and cone beam computed tomography (CBCT). (Fig.3)Implant Installation: fig(4)

After the socket has been prepared and ready to receive the implant, the implant has been picked up by driver when its still in the sterilized pack . The driver was mountain on the ratchet and slowly inserted inside the prepared socket .

Fig. (1) Preoperative photograph show the area of interest (upper let cenftral incisor).

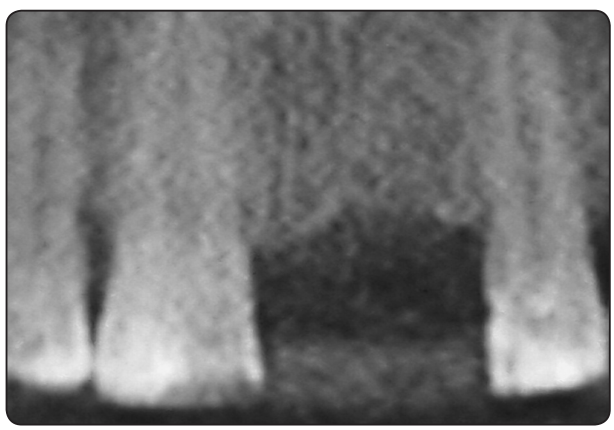

Fig. (2) Preoperative periapical x-ray

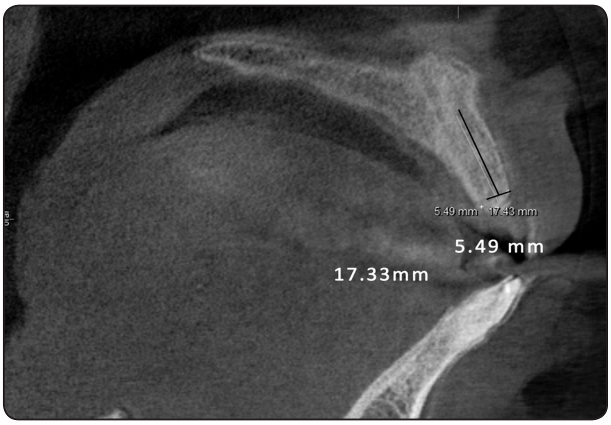

Fig. (3) sagittal cut on (CBCT) show measurement of bone height and width

Fig. (5) Ultrasound machine*

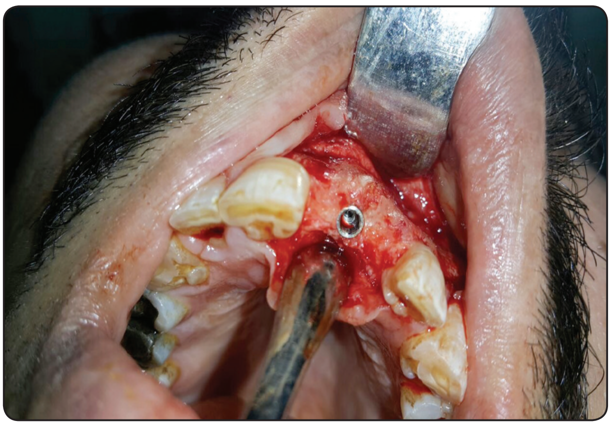

Fig. (4) Implant installation inside the prepared socket.

Fig. (6) Application of LIPUS on implant site

Application of LIPUS:

Low intenisity pulsed ultrasound waves will be started on the first postoperative day using a commercially available therapeutic ultrasound device (Ultrasound machine digesonic CHUNGWOO). The device transmits pulsed ultrasound signals with a burst width of 200 _s containing 1.5MHz sine waves, with a repetition rate of 1 kHz and a spatial average-temporal intensity of 40 mW/cm2. The implants, will be irradiated for 10 min twice a day for 21 days.

Post-Operative:

Fig. (7) loading of the final restoration after 3 months (full porcelain crown)

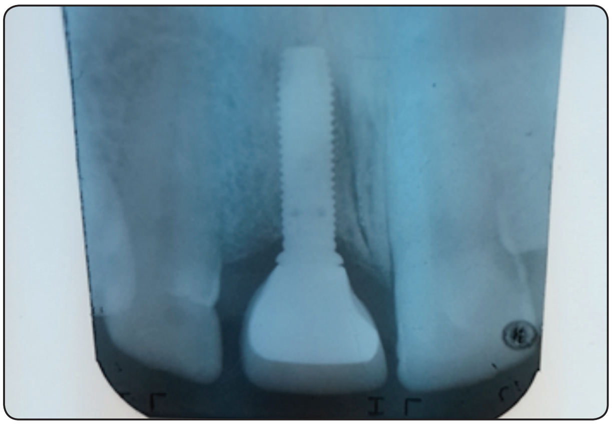

Fig. (8) periapical x-ray after crown loading after three monthes

Fig. (9) The case before and after operation

RESULTS

The aim of the present study was to evaluate The effect of low-intensity pulsed ultrasound on the osseointegration of titanium dental implants .

Ten implants were placed in ten patients each one receives one implant. The patients were 6 males and 4 females ranged in ages from 25 to 40 years. All the implants were placed in maxilla. Observations were made postoperatively at time of implant placement then after 1 month, 3 months , 6 months and one year follow up periods for pain, crestal bone loss, stability, papillae height and mean probing depth.

Data analysis was performed in several steps. Initially, descriptive statistics for each case results. One way ANOVA followed by pair-wise Tukey post-hoc tests were performed to detect significance between preparation cases. Statistical analysis was performed using Graph-Pad Prism-4 statistics software for Windows. P values ≤0.05 are considered to be statistically significant in all tests.

Crestal bone loss (bone height)

Peri-implant crestal bone level was measured using standardized intraoral periapical radiographs with paralleling technique at 1, 3 , 6 months and one year after the operation. Reference points for the linear measurements were the most coronal margin of the implant collar in relation to the most coronal point of bone -to- implant contact.

Descriptive statistics of crestal bone loss results expressed in (mm) as function of investigation time are summarized in table (3) and graphically drawn in figure (10)

It was found that the bone loss at baseline recorded (0mm) mean value, after 3 months the mean of crestal bone loss was (0.29675mm) with minimum value (0.1) and a maximum value (0.505) and a percentage change (3.297222%), after 6 months the mean of crestal bone loss was (0.4205mm) with minimum value (0.17) and a maximum value (0.66) and a percentage change (4.672222%), while after one year the mean of crystal bone loss (06232mm) with minimum value (0.21) and maximum value (0.82) and percentage change (5.982222%).

TABLE (1) Descriptive statistics of crestal bone loss results (Mean±SD) as function of investigation time

	After one month	After3 months	After 6months	After one year
Minimum	0	0.1	0.17	0.21
Maximum	0	0.505	0.66	0.82
Mean	0	0.29675	0.4205	0.6232
SD	0	0.076001	0.099132	0.152
Median	0	0.285	0.4	0.52

The crestal bone loss increased significantly by time as indicated by one way ANOVA test ($p<0.05$). Pair-wise Tukey's post-hoc test showed non-significant ($p>0.05$) difference between 6 months and one year.

TABLE (2) Comparison of crestal bone loss results (Mean±SD) as function of investigation time

Parameter	Time	Mean±SD	Change %	Tukey rank	ANOVA
Crystal bone loss	After one month	0±0	---	C	P value
	After 3 months	0.29675±0.0876	3.297222	B	<0.0001*
	After 6 months	0.4205±0.1336	4.672222	A	
	After one year	0.6232±0.152	5.982222	AB	

Different large letter in same column indicating significant within veneering (Tukey p<0.05) ****; significant (p<0.05)***

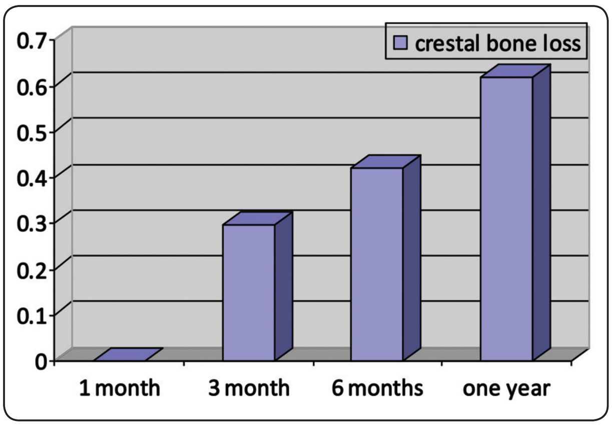

Fig. (10) Column chart with trend line showing crestal bone loss mean values at different investigation time

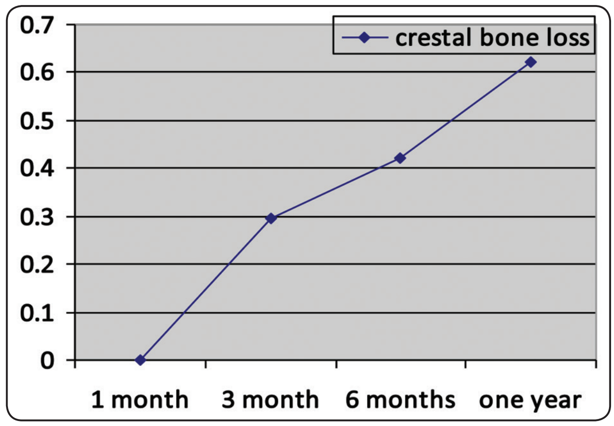

Fig. (11) Linear chart with trend line showing crestal bone loss changes at different investigation time

Implant stability

Descriptive statistics of implant stability measured by perio-test as function of investigation time are summarized in table (5) and graphically drawn in figure (48)

It was found that the perio-test at baseline recorded highest stability mean value (23.3 value) with minimum value (16.26) and a maximum value (30.34), after 3 months the mean of implant stability increased to (11.05 value) with minimum value (6.59) and a maximum value (15.51) and a percentage change of (52.57511%), after 6 months the mean of implant stability was (2.95 value) with minimum value (0.68) and a maximum value (5.22) and a percentage change (87.33906%) while after one year the mean of implant stability was (1.25 value) with minimum value (0.25) and a maximum value (2.32) and a percentage change (93.256%).

TABLE (3) Descriptive statistics of implant stability results as function of investigation time

	One month	After 3 month	After 6 months	After one year
Minimum	16.26	6.59	0.68	0.25
Maximum	30.34	15.51	5.22	2.32
Mean	***23.3***	***11.05***	***2.95***	***1.25***
SD	***7.04***	***4.46***	***2.27***	***0.25***
Median	23.3	11.05	2.95	1.45

The implant stability increased significantly by time as indicated by one way ANOVA test followed by pair-wise Tukey's post-hoc test (p<0.05).

TABLE (4) Comparison of implant stability results (Mean±SD) as function of investigation time

Parameter	Time	Mean±SD	Change %	Tukey rank	ANOVA
Implant stability	After one month	23.3±7.04	----	A	P value
	After 3 month	11.05±4.46	52.57511	B	<0.0001*
	After 6 months	2.95±2.27	87.33906	C	
	After one year	1.25±0.25	93.256	CB	

Different large letter in same column indicating significant (Tukey p<0.05) ****; significant (p<0.05)***

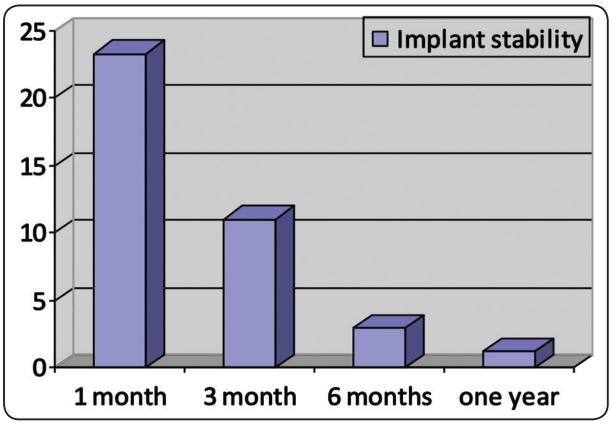

Fig. (12) Column chart with trend line showing implant stability mean values at different investigation time

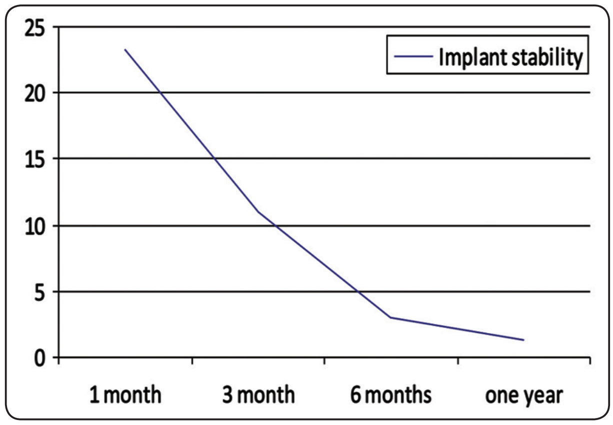

Fig. (13) Linear chart showing implant stability changes at different investigation time

DISCUSSION

X-rays investigation (periapical and cone beam) were utilized in this The study showed a positive effect of LIPU application on dental implant osseointegration specifically in the early osseointegration period.

LIPUS given for 10 min twice a day for 21 days had a beneficial effect on osseointegration around dental implants. The microarchitecture of bone is the most extensively studied component of its quality, and CT is an accurate and powerful tool for resolving the microsized architecture and density of trabecular bone, which made up the cancellous bone around the implants. The three dimensional variables of trabecular microstructure that are related to the mechanical properties of cancellous bones, bone volume, tissue volume fraction, bone surface, bone volume ratio, trabecular thickness, and trabecular separation, were significantly better on the LIPUS-treated side than on that of the control side.

LIPU also has direct effect on cell physiology by increasing the incorporation of calcium ions in cartilage and bone cell cultures and by stimulating the expression of numerous genes involved in the healing process as mentioned by Rubin C , Bolander M and et al 2001.[8,12]

In addition to modulating gene expression, ultrasound may enhance angiogenesis and increase blood flow around the fracture[13]

Besides these molecular interactions, the acoustic pressure waves facilitate fluid flow, which increases nutrient delivery and waste removal (acoustic streaming phenomenon), thus stimulating proliferation and differentiation of the fibroblasts, chondroblasts and osteoblasts.[8]

Different techniques have been proposed for the measurement of implant stability like Periotest® (Gulden, Bensheim, Germany) or Dental Fine Tester® (Kyocera, Kyoto, Japan) systems. However, their lack of resolution, poor sensitivity and susceptibility to operator variables have been criticized. [15]

Recently, periotest has become a popular option to provide an objective measurement of implant stability. Biophysical stimulation on bone tissue has been investigated both experimentally and clinically by numerous studies, positive outcomes have been reported by many authors for the treatment of bone infections, delayed unions and non-union of fractures, bone necrosis and integration of intercalary bone grafts.[1,6-5] Several studies demonstrated that LIPU stimulates osteogenesis during bone growth and repair.[28,29]

The LIPU treated subjects showed significantly higher bone implant contact ratio in the late osseointegration period but not in the early period. According to these results it may be concluded that although LIPU treatment increases the bone volume and bone area even in the early postoperative period, changes in bone to implant contact occurs after the 3rd week of application

This study is planned to assess the osseointegration and to assess the changes in the soft tissue profile with low-intenisty pulsed ultrasound. For this purpose; ten implants were placed in ten patients each one receives one implant. The patients were 6 males and 4 females ranged in ages from 25 to 40 years. All the implants were placed in maxilla. Observations were made postoperatively at time of implant placement then after 1 month, 3 months and 6 months follow up periods for pain, crestal bone loss, stability, papillae height and mean probing depth.

The current study has documented successful implants for all patients throughout this study. Primary stability was prerequisite for final stability and osseointegration of all cases. Moreover, the clinical criteria of success as well as the radiographic criteria were considered an important prerequisite for osseointegration. This was in agreement with those of Davies[(19)], and Smith[(18)].Although the radiographic criteria are confirmatory rather than expletory for detection of peri-implantitis and marginal bone loss which is minimum due to the use of ultra sounds with more osseointegration around implants . The clinical criteria were of the same importance to prove the success of an implant.

Crestal bone loss in this study, was evaluated on the mesial and distal surface of implant using standardized periapical radiographs. This was done using a parallel long-cone technique with film holders.

Asimilar approach was employed in prior prospective clinical studies. However, Cameron et al[(22)] demonstrated that film position did not significantly influence the accuracy of measurements of the image. This was true if the tube head maintained at less than 20 degrees from perpendicular to the long axis of the implant. Therefore, this technique is considered reliable and reproducible procedure in evaluating crestal bone loss.

The final outcome of bone preservation and/or resorption was done at each of the time interval (1 month,3 month, 6 month and one year postoperative). The radiographic images were subjected to computerized software RayMage® to measure crestal bone loss. While the actual length of implant was known, so the amount of bone resorption could be determined through millimetric readings of the pixels by computer program.

The current study has present a statistically significant marginal bone loss after 6 months was explained by the effect of remodeling after surgery. However, the amount of marginal bone loss at one year postoperative was not of statistically significant.

This was explained by the physiologic stationary time for bone with minimal amount of bone resorption. Additionally, statistically significant difference in the amount of bone loss between the baseline interval (1 month postoperative) and the final one at one year.

Implant stability in this study, was evaluated using digital periotest device for assessment of osseointegration of dental implant. The periotest scale ranges from -8 to +50. In all cases, the signs of osseointegration were interpreted by periotest values after 1 mouth postoperative. The cases done in this study were followed for about 12 months postoperative, They shows increase in implant stability by time by giving a negative value which is quite significant in terms of good osseointegration. Periotest device enable us to assess osseointegration noninvasively and objectively, it also helps to optimize our decision whether or not an implant ready for functional loading.

CONCLUSION

According to the results of this study can concluded that:

- The Low Intensity Pulsed Ultra sound (LIPU) application may accelerate and promote bone healing around dental implants leading to a higher quality and faster osseointegration.
- The LIPU may stimulate bone regeneration, shorten the total osseointegration time of dental implants and promote the osseointegration quality.
- The x- rays investigation (periapical and cone beam) were utilized in this The study showed a positive effect of LIPU application on dental implant osseointegration specifically in the early osseointegration period.
- For patients who suffer from missing or badly damaged teeth, dental implants are an excellent solution.
- Endosseous dental implants may be considered as the most popular treatment option for partially and fully edentulous patients. It is generally accepted that implant success is primarily dependent upon or achieved by osseointegration, a direct contact between the implant surfaces and living bone.
- Ultrasound is a form of energy that is transmitted through biological tissues as high-frequency acoustic waves, which is widely used in medicine as a diagnostic, therapeutic and operative tool.
- LIPU application is simple to use individually and no side effects of the treatment have been reported so far. Therefore, it seems possible to use this application clinically to strengthen dental implant osseointegration and stability.

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