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Effect of Laser versus PRF Application on Buccal Bone Thickness and Crestal Bone Loss around Mandibular Implant Supported Overdenture: Randomized Clinical Trial.

Sara M Bahaa[1*], Lobna Mohamed Abdel-aziz[2], Shereen M. Kabeel[3], Marwa M. Ebida[1], Mohamed Yehia Abdelfattah[4], Samir Ali Elborolosy[5], Sara M Shabaan[6].

1* Lecturer at Removable Prosthodontic Department, Faculty of Dental Medicine for girls, Al-Azhar University, Cairo, Egypt.
2. Lecturer of Oral Medicine, Periodontology, Diagnosis and Oral Radiology, Faculty of Dental Medicine for girls, Al-Azhar University, Cairo, Egypt.
3.Professor of Removable prosthodontics, Faculty of Dental Medicine for girls, Al-Azhar University, Cairo, Egypt.
4. lecturer, Oral Biology Department, Faculty of Dentistry, Beni-Suef University, Beni-Suef, Egypt.
Lecturer, Oral Biology Department, School of Dentistry, Newgiza University, Egypt.
5. Lecturer, Oral and Maxillofacial Surgery Department Faculty of Dentistry. Beni-Suef University, Egypt.
6. Lecturer at Removable Prosthodontic Department, Faculty of Oral and Dental Medicine, Badr University, Cairo, Egypt.
Corresponding author: Sara M Bahaa
Email: sarabahaa86@gmail.com

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Abstract: Purpose: The study was conducted to evaluate the crestal bone loss, and the buccal plate thickness (BPT) around dental implants as influenced by diode laser versus PRF using (CBCT) Cone Beam Computed Tomography, in implant supported over denture. Material and method: 24 completely edentulous patient except for the lower first premolars were selected and received lower implant supported over denture. The patients were randomly and equally divided into two groups, where group (A) subjected to PRF before implant insertion and group (B) subjected to low level laser treatment LLLT immediately after implant insertion, then after 3rd, 7th, 15th days from implantation. Using CBCT, both the crestal bone loss and buccal plate thickness were measured at the time of implantation, and 9 months after implant insertion. Results: The crestal bone loss differences between the two-time intervals were tested at (P- value ≤ 0.001). The two groups (A&B) were equal at baseline (10±0.00 mm), and both groups showed significant bone loss at 9 months, where group (A) was (8.74±0.12 mm) and (8.05±0.53) for group (B). Comparing the two groups at 9 months, revealed statistically significant increase for group (B) in crestal bone loss as it achieved the highest percentage of bone loss. Conclusion: According to the present study, it could be concluded that, both techniques LLLT and PRF are successful and the PRF showed better results comparing with LLLT regarding crestal bone loss and buccal plate thickness around dental implants

Keywords: Implant supported over denture, laser, PRF, Buccal plate

Introduction

The condition of complete edentulism is a serious problem especially when neglected for a long time, it could lead to advanced bone resorption, poor mastication and physical impairment. Implant-supported overdentures was provided to be a successful rehabilitation modality for completely edentulous patients, particularly those with severely resorbed mandibular arch, since the patients can experience issues using conventional denture. It has been proven that, the implant-supported overdenture can enhance speech, masticatory function, diet, comfort, and generally patient satisfaction [1-4].

The biotechnical process of osseointegration is the back-bone of osseo-integrated implants. Numerous strategies have been proposed to reduce the marginal bone loss, enhance and accelerate healing in endosseous implants, but the majority of these measurements focus on implant surface features, which are under the manufacturer's control [5].

Recently, Guided Bone Regeneration (GBR) has been developed and it was found to be efficient with the cases of insufficient alveolar bone height or width. Guided Bone Regeneration is a successful therapeutic modality that is used to obtain bone regeneration, which have been quickly evolved ever since dental implants were introduced as an effective method to anchor the dental prosthesis to the alveolar bone. It is among the methods that has been thoroughly documented for hard tissue regeneration, either before or during implant implantation. [6-8].

The centrifugation of human venous blood can be used to separate the platelet concentrate, which contains platelet-rich fibrin (PRF). PRF is widely used as a biological scaffold in medical and dental fields for post-operative rehabilitation, healing, and tissue regeneration. The platelet rich fibrin preparations were stated to encourage artificial wound closure [9].

Earlier clinical studies showed that, PRF influences soft and hard-tissue regeneration. The PRF local application has proven to improve tissue regeneration of critical sized bony defects and enhances bone regeneration in experimental animals. The results of the studies and researches suggested the use of the PRF alone or with other materials as a biological scaffold [10-13].

There are two main applications of laser in the field of dentistry, at surgery or as a bio-stimulant. Bio-stimulation is the process of stimulation to the healing and tissue regeneration processes. The LLLT is the type of laser that is used for this purpose [14].

In the medical field, laser light irradiation has been utilized and has demonstrated stimulatory effects on collagen synthesis, fibroblast proliferation, and wound healing. The low level laser treatment, has been proposed as a way to enhance and quicken the healing process of the bony tissues. The synthesis of adenosine triphosphate and the mitochondrial respiration has shown to increase using LLLT. Additionally, the bone irradiation, primarily using the infrared wavelengths, exhibits better proliferation for the osteoblast, deposition of the collagen, and new bone formation comparing with the non-irradiated bone. [15,16].

The successful rate of the dental implant is influenced directly through the amount of initial resorption of the bone at the implant/ bone interface. Reducing the loss of crestal bone around the implant has been a constant goal. The impact of low-level laser treatment on the interface between the implant and the bone is still unclear. [17]

The survival rate and excellent prognosis of the dental implant relies on the bone changes around osseo-integrated implant. Thus, the present study was performed to compare the effect of LLLT versus PRF application on the buccal plate thickness and crestal bone loss around mandibular implant-supported overdenture.

MATERIAL & METHODS

Study design

The current study represented a randomized clinical trial, and 24 patients were chosen from The Outpatient Clinic of Periodontology Department, Faculty of Dental Medicine, Al-Azhar University from January 2022 to October 2022. Prior to participation, all the patients received full information about the procedures and had signed a written consent.

Sample size:

The calculation of the sample size was computed using the version 3.1.9.7. of G*Power software, and 24 samples were found to be sufficient to identify a mean effect size of 0.35 with (1-β=0.90) power, at $p \leq 0.05$, to detect the difference between the two study groups (Laser and PRF). The calculation of the sample size revealed that, there was a 90% chance null hypothesis rejection of no significant effect of the interaction with12 patients in each group.

Patient's criteria:

The Ethics Committee of Faculty of Dental Medicine for Girls (Girl's branch) had approved the study design, and was given the following code REC 15-074. PICOS criteria: PICOS (Patients, Intervention, Comparison, Outcome, and Study Design) criteria for this research was as follows: Patient (P): Completely edentulous patients except for lower first premolars indicated for extraction. There was no gender exception. Intervention (I): Use platelet-rich fibrin (PRF) factors during implant placement. Comparison (C): Application of LLLT as bio-stimulation. Outcome (O): Primary outcomes: Changes of Buccal plate thickness (BPT) and Marginal bone loss (MBL).

All the patients were selected to be completely edentulous except for lower first premolar bilaterally, which required extraction, their age ranged between 55-65 years, with well-developed ridge, free from any signs or symptoms of temporomandibular disorders and/ or neuromuscular diseases, all the patients were chosen to have class I Angle classification.

The patients with cancer, history of radiation or chemotherapy for cancer in the past five years, psychiatric disorders, uncontrolled diabetes, and former or current smokers were excluded.

Patient grouping

At the time of the operation, computer-generated tables were used to randomly allocate eligible patients into one of two groups as follows: group (A) 12 patients who received PRF and group (B): 12 patients who received laser application, immediately after dental implant insertion (zero) then, 3sessions of LLLT application on the 3rd, 7th, and 15th days of implantation from the buccal mucosal side.

Radiographic evaluation

The medical and dental histories were taken from each patient, the oral examination was done and the radiographic evaluation using CBCT was performed using (Planmecca Viso G7, Imaging Sciences, Finland). The bone quality, width, and height around the premolars were checked using CBCT.

A- Phase one surgery:

1- PRF preparation for group (A):

Ten milliliter of intra-venous blood samples were obtained and placed in two plastic tubes coated with glass, without adding of anticoagulant. The tubes were once centrifuged for ten minutes at 3000 rpm. By the end of the procedure, 3 layers were performed: The base RBC layer, the middle Fibrin clot layer (PRF), and the upper serum layer Platelet-Rich Plasma. [18] Using tissue forceps, the clot of plasma rich fibrin was removed from the tube and remain in a sterile cup for about ten minutes to allow the proper serum to be released.

2-Teeth extraction:

The patient underwent mouth rinse, for one-minute using 0.20% chlorhexidine gluconate (Kahira Pharmaceutica and Chemical Industries Company, Cairo, Egypt) once before extraction. The lower first premolars were extracted a traumatically using a proteome under local anesthesia using 2% lignocaine with 1:80,000 adrenaline concentration to provide vasoconstriction. Curettage and irrigation using saline and warm Betadine were performed to remove any apical granulation tissues. Using a periodontal probe, the thickness and height for the bone plate buccally and lingually were clinically inspected.

3- Osteotomy preparation and implant insertion:

The site for the implant was prepared, using sequential drills of the surgical kit, to the required dimensions, with (2000 rpm) low speed, under copious normal saline irrigation. The surgical procedures were carried out by the same operator, using the same type and size of implant to all the patient of the two groups (A&B).

a- For group (A): Between 2 glass slides, the PRF clot with RBCs thin layer, was thinning until it became a membrane then it was applied to the buccal plate prior to implant insertion. Tapered, self-tapping, screw-vent titanium dental implants with the same dimensions were selected to all patients. The manual ratchet torque handle was used, to insert the implant (Neobiotech, Co., Seoul, Korea), till the whole length was covered with bone, then punch was closed using an interrupted non-resorbable suture.

b-For group (B): Each patient was exposed to four applications of LLLT bilaterally. The semiconductor diode laser (AMD Picasso, Indianapolis, IN 46240, United States.) with 0.5W power and 810nm. wavelength was used, at the site of the implant, as shown in Figure (1)

Laser irradiation was applied to buccal plate intra-osteotome immediately after implant insertion, it was applied for 40s, using power density 0.5 MW, laser diameter: 1 cm^2, beam shape was around in a continuous mode bio-stimulation. Then, each subject received 3 sessions of LLLT on the 3rd, 7th, and 15th days of implantation from the buccal mucosal side [19].

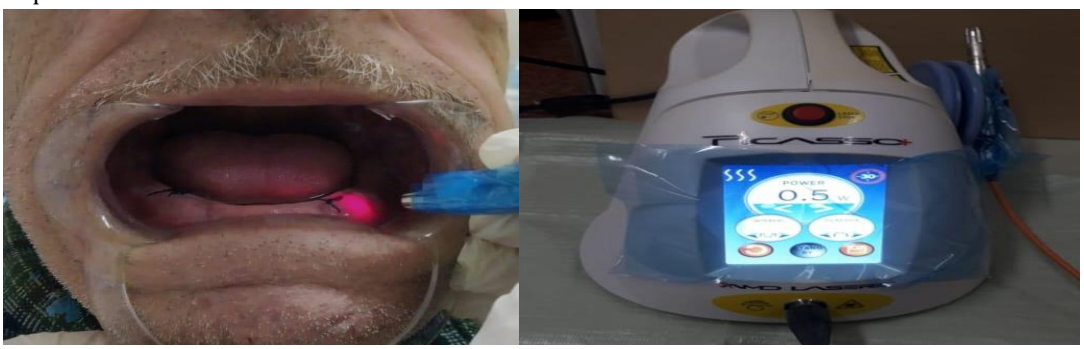

Figure (1): low level laser application.

Removable prosthesis construction:

After a month of healing period, complete denture was fabricated, where preliminary impressions were made for the maxillary and mandibular arches using alginate impression material (Cavex Impression, Netherlands) which was poured to obtain the study cast. The secondary impression for upper and lower arches was performed using medium body rubber base impression material (Zeta Plus Impression Material, Italy) with a custom-made tray. The record base was fabricated over the final cast from cold cured acrylic resin (Acrostone for Manufacturing and Import Compony, Cairo, Egy.), where the centric relation was obtained with wax wafer technique.

Anatomical acrylic teeth (Acrostone for Manufacturing and Import Compony, Cairo, Egy.) were set up in a bilateral balanced occlusal scheme. Try-in for the waxed denture was performed. The dentures were processed into heat-cured PMMA (Acrostone for Manufacturing and Import Compony, Cairo, Egy.) and checked intraorally. The denture fitting surface was relieved over the implant position to avoid pressure over the implant before attachment applications. Instructions were given to the patient for the use and maintenance.

B- Phase two surgery:

After 3 months following implant insertion, a punch out was created, and the cover screws were removed and the ball abutments were applied.

Removable prosthesis application:

Patients were recalled by the end of the 3rd month following implant insertion, to receive the attachments (Neobiotech, Co., Seoul, Korea). The ball abutments of 2mm in length and 3.5mm wide, were tightened by hand torque. The spacers were applied over the ball abutments, housings were placed over the abutments and the seat for each housing was prepared in the lower denture-fitting surface. The escape holes were created from the lingual aspect of the lower denture to provide escape area for the excess material. Autopolymerized resin (Acrostone for Manufacturing and Import Compony, Cairo, Egy.) was prepared and placed in the prepared holes then, the denture was secured at its position. Following complete setting of the resin, the spacer was discarded, the denture was then finished and polished as shown in Figure (2).

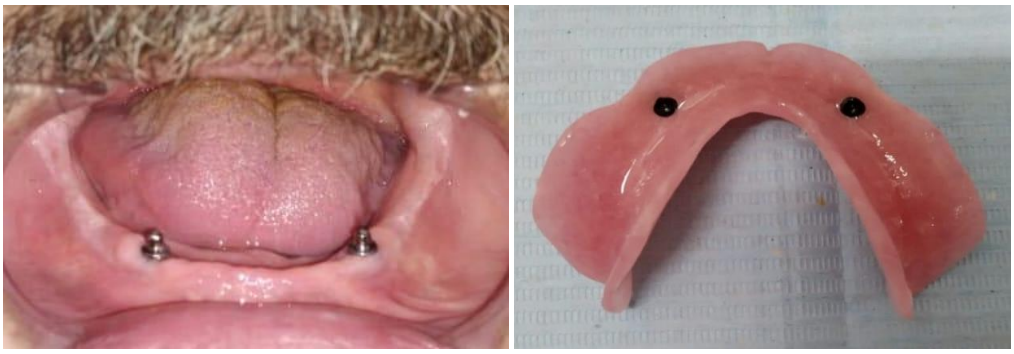

Figure (2): Application of ball and socket attachment to the lower denture.

Treatment Outcomes

Radiographic evaluation was performed for each subject after implant placement at baseline (T0), and after 9 months from implant insertion (T1) to measure Marginal Bone loss (MBL), and buccal plate thickness (BPT).

Measuring the Marginal bone loss

Navigation was done on the multiplanar screen, until the sagittal cut and reformatted panorama displayed the implant's correct view. The tools of the software were used to draw a line on the buccal, lingual, mesial, and distal forms, from the apical edge of the implant to the alveolar crest

Measuring the buccal bone thickness

Measurements of the buccal bone (in millimeters) were taken starting at the implant's radius, which represents the point where the implant and bone meet. The thickness of the buccal bone was measured for 5 mm along an axis that extended from the implant's neck (M0) towards the apical border (M5) [20] as shown in Figure (3).

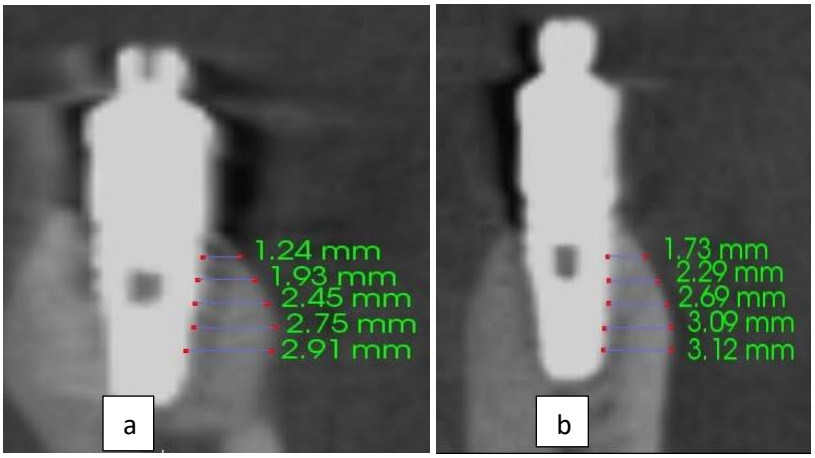

Figure (3): Measurements for buccal plate thickness (a): for group (A), (b)for group (B).

RESULT

Statistical analysis

The SPSS statistical program has been used to gather, edit, code, and enter data (version 25, IBM Co. USA). The quantitative data were introduced as mean, standard deviations, and ranges once their distribution was determined to be parametrized. Statistical analysis for results was carried out using Kruskal-Wallis then pairwise comparisons using (Mann-Whitney Test) between groups. The following equation was used to calculate the percentage of change:

$$Percentage\ of\ change\ (\%) = \frac{Baseline\ value - the\ value\ after\ time\ t}{Baseline\ value}$$

After time t, the baseline value changed to a higher value, as indicated by the percentage change's negative value, whereas the baseline value changed to a lower value, as indicated by the percentage change's positive value (t). The p-value was statistically significant for $P \leq 0.05$ (95% significance level). The data normality was tested by Shapiro-Wilk test.

I-Marginal Bone Loss

The variation in MBL between the two-time intervals was evaluated at (P- value ≤ 0.001). The two groups showed equal results at the baseline (10±0.00) and both of them showed significant bone loss at 9 months, where group (A) and group (B) measurements were (8.74±0.12 mm) and (8.05±0.53) respectively. While comparison of the two groups was carried out at 9 months, there was a statistically significant increase in MBL for group (B) as it attained the highest percentage of bone loss as listed in Table (1).

II-Buccal plate thickness

The mean of the buccal plate thickness (BPT) in group (A) was (1.70±0.15 mm) in the baseline then decreased to (1.59±0.16 mm) after 9 months, and the percentage of change showed to be 6.5%. The difference in buccal plate thickness between the two-time intervals (P- value > 0.05) was not significant statistically. The mean of BPT for group (B) was (1.84±0.94 mm) in baseline then decreased to (1.42±0.85 mm) after 9 months, showing a percentage of change of 22.8%. while there was a highly statistically significant difference in buccal plate thickness between the two-time intervals at (P- value ≤ 0.001). Comparing of the BPT readings for both groups (A&B) at nine months there was a statistically significant decrease in group (B) (1.42±0.85) than group (A) (1.59±0.16) at (P- value ≤ 0.019)

Table (1): Mean ±SD of marginal bone, Bone Density, and Buccal plate thickness loss for both groups at different time intervals.

Group	Baseline	9 Months	P-Value*	Percentage of change
Marginal Bone Loss				
Group (A)	10±0.00	8.74±0.12	**0.000^{HS}**	**12.6 %**
Group (B)	10±0.00	8.05±0.53	**0.000^{HS}**	**19.5 %**
P- Value**		**0.000^{HS}**		**0.000^{HS}**
Buccal plate thickness				
Group (A)	1.70±0.15	1.59±0.16	**0.160^{NS}**	**6.5 %**
Group (B)	1.84±0.94	1.42±0.85	**0.000^{HS}**	**22.8 %**
P- Value**	**0.059^{NS}**	**0.019^{S}**		**0.023^{S}**

* P value for intra-group comparisons (Baseline Vs. 9 months), and conceded statistically significant if P ≤.05.

** P-value for inter-group comparison (Kruskal-Wallis test).

$^{(S)}$ statistically significant at P ≤ 0.05 – $^{(HS)}$ highly significant P-value ≤ 0.001

$^{(NS)}$ Non-significant P-value > 0.05.

DISCUSSION

Completely edentulous patients with conventional dentures frequently complain about lower denture reduced retention, stability and fitting to the denture foundation tissues. The issue of bone resorption that arises after tooth extraction has a direct impact over the future implant placement, prosthetic application and the esthetics. [21,22]

However, the implant's success and prognosis can be enhanced using appropriate stimuli, such as LLLT and PRF as their application proven to enhance osseointergration and diminish the bone resorption [23].

The diode laser is a low-level laser type used to promote ossification as it was found to possess greater tissue transmission efficiency compared to other laser systems. Previous studies revealed that, the differences between LLLT and conventional implants were unsignificant according to Bajaj et, al. However, the LLLT was applied at the site of the implant for group (B) in the current study, as it was proven to be a non-invasive technique which encourage collagen synthesis, promote the ATP production, growth factors release, lymphocyte, macrophage, fibroblast and other cytokines. Furthermore, the LLLT enhances microcirculation, which subsequently reduces post operative edema and discomfort [24-27].

Additionally, LLLT was proven to increase bone formation, it was stated that, laser application in immediately loaded implants, increases the bone density and preserves the supporting alveolar ridge, comparing with implants without laser application [24, 28, 29].

It was found that, the PRF was easily handled and get from patient's venous blood centrifugation, also it is perfect in the healing process, reducing post-operative pain, promote healing, and preventing bone loss, and stimulate new bone formation [30-34]

Bony changes at the implant/bone surface are of great consideration in predicting the success, prognosis and the survival of the implant so, the main goal for the operator is to provide the least amount of bony loss around the implant. [35] It was found that, the 1st three months after teeth extraction are critical, and the highest rate of bone resorption occurs at the 1st three months, while the pattern for the resorption of the bone was found to occurs in both directions apicocoronally and buccolingually [36]

The buccal plate thickness morphological evaluation, is of great interest to the implantologist before implant placement and also during the follow-up sessions to predict the treatment reliability. The CBCT has been used successfully to evaluate the buccal bone dimensions and changes prior to and following implant insertion. [37-40] The current study used the CBCT for periodic evaluation of the marginal bone loss and BPT at baseline and after 9 months of implant insertion.

Bone resorption mostly occurs in the first year following prosthesis installation, and significantly declines in subsequent years. By the end of the 1st year, the average alveolar bone resorption was reported to be between 1.2 and 2.0 mm, and then 0.1 mm yearly after that. [41] According to the current study, comparing the marginal bone loss for groups (A&B) after 9 months, group (B) experienced statistically significant increase in the marginal bone loss. The two groups(A&B) showed varying degrees of marginal bone loss about 1.95 ± 0.07mm for group (B) and 1.26, ± 0.16mm for group (A).

These finding could be a result of bone osteotomy, the healing process, reorganization and remodeling of the tissues following surgical trauma to the bone and periosteum. It also might be considered an immediate reaction following the prosthesis loading. The concentration of the applied forces on the crestal bone instead of forces distribution along the whole bone/implant surface, may be the reason for crestal bone loss [42]. Oh et, al., claimed that secondary factors may be the reasons for early bone loss around the implants, including the surgical and mechanical trauma which may happen at the time of implant placement, or through occlusal forces, collar design and micromovements of the implant. [43]

The evaluation of BPT according to the current study showed that, for the group (A) the readings were (1.70±0.15 mm) at the baseline readings, then decreased to (1.59±0.16 mm) after 9 months. The difference in buccal plate thickness between the two times intervals was not statistically significant. While the BPT for the group (B) was (1.84±0.94 mm) at the baseline readings, then reduced to (1.42±0.85 mm) after 9 months, the difference in buccal plate thickness between the two times intervals was statistically highly significant. By comparing the BPT of both groups (A&B) at 9 months, there was a statistically significant reduction in group (B) than in group (A).

Unfortunately, there is a lack of researches evaluating the possible changes of the buccal plate thickness with dental implants [44]. Our results showed to be in agreement with Cortese A et al. as they reported that, the modified split crest technique, that used in combination with platelet rich fibrin approved to be safe, dependable, and improved the therapeutic result, for the subjects with deficient horizontal bone, comparing with conventional techniques through preservation of the alveolar height. [45]

According to the classic criteria defining the success of dental implants which allowed bone loss for about 1-1.5mm. during the 1st year following implant loading and less than 0.2 mm annually after that, thereafter both techniques are considered successful and PRF showed promising results compared with LLLT.

CONCLUSION

According to the present study, it could be concluded that, both techniques LLLT and PRF are successful and the PRF showed better results comparing with LLLT regarding crestal bone loss and buccal plate thickness

around dental implants. However, additional studies are required on this topic, with a bigger sample size and longer follow-up periods.

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CONFLICT OF INTEREST

Authors have no conflict of interest.

References:

1. Mameno T, Wada M, Otsuki M, Okuno I, Ozeki K, Tahara A, et al. Risk indicators for marginal bone resorption around implants in function for at least 4 years: A retrospective longitudinal study. J Periodontol. 2020; 91:37-45.
2. Sharka R, Abed H, Hector M. Oral health-related quality of life and satisfaction of edentulous patients using conventional complete dentures and implant-retained overdentures: An umbrella systematic review. Gerodontology. 2019; 36:195- 204.
3. Boven GC, Raghoebar GM, Vissink A, Meijer HJ. Improving masticatory performance, bite force, nutritional state and patient's satisfaction with implant overdentures: a systematic review of the literature. J oral Rehabil. 2015; 42: 220- 33.
4. Sivaramakrishnan G, Sridharan K. Comparison of implant supported mandibular overdentures and conventional dentures on quality of life: a systematic review and meta-analysis of randomized controlled studies. Aust Dent J. 2016; 61: 482- 8.
5. Pandey C, Rokaya D, Bhattarai b. Contemporary Concepts in Osseointegration of Dental Implants: Biomed Res Int. 2022; 8:11-17.
6. Poomprakobsri K, Kan JY, Rungcharassaeng K, Lozada J, Oyoyo U. Exposure of barriers used in guided bone regeneration: Rate, timing, management, and effect on grafted bone—A retrospective analysis. J Oral Implantol. 2022; 48: 27–36.
7. Veljanovski D, Baftijari D, Zoran Susak Z, Stojanovska A. Implant site guided bone regeneration and pontic site ridge preservation: a case report. Contributions. Sec. of Med. Sci. 2021; 2:103-8.
8. Retzepi M, Donos N. Guided Bone Regeneration: biological principle and therapeutic applications. Clin Oral Impl Res.2010; 21:567-76.
9. Pitzurra L, Jansen ID, de Vries TJ, Hoogenkamp MA, Loos BG. Effects of L-PRF and A-PRF+ on periodontal fibroblasts in in vitro wound healing experiments. J Periodontal Res 2020; 55:287-95.
10. Strauss FJ, Nasirzade J, Kargarpoor Z, Stähli A, Gruber R. Effect of platelet-rich fibrin on cell proliferation, migration, differentiation, inflammation, and osteoclastogenesis: A systematic review of in vitro studies. Clin Oral Investig 2020; 24: 569-84.
11. Mahendran K. A little goes a long way: The cruise of platelet concentrates in dentistry. J Interdiscip Dent 2019; 9:97-8.
12. Balaji VR, Thiagarajan RK, Niazi TM, Ulaganathan G, Manikandan D. Antimicrobial effects of platelet rich fibrin: A systematic review on current evidence of research. J Interdiscip Dent 2021; 11:2-10.
13. Desai AK, Kumar N, Dikhit P, Koikude SB, Bhaduri S. Efficacy of platelet-rich fibrin in secondary cleft alveolar bone grafting. Craniomaxillofac Trauma Reconstr Open 2019; 3: s-0039.
14. Miller RJ. Lasers in oral implantology. Dent Pract. 2006:112-4.
15. Niemz MH. Laser-Tissue Interactions: Fundamentals and Applications. Springer; 2019.
16. Parker S. Low-level laser use in dentistry. Br Dent J. 2007; 202:131-8.
17. Gulati P, Kumar M Issar G Thakral A Effect of low level laser therapy on crestal bone levels around dental implants-A pilot study. Clin Implant Dent Relat Res. 2020; 22:739-46.
18. Mijiritsky E, Assaf H D, Peleg O, Shacham , Cerroni L , Mangani L. Use of PRP, PRF and CGF in Periodontal Regeneration and Facial Rejuvenation—A Narrative A Narrative Review. Biology 2021; 10: 317-23.
19. Memarian J, Ketabi M, Amini S. The effect of low-level laser 810 nm and light-emitting diode photobiomodulation (626 nm) on the stability of the implant and inflammatory markers interleukin-1 beta and prostaglandin E2, around implants. Dent Res J. 2018; 15:283-8.
20. Meijer, HJA, Slagter, KW, Vissink, A, Raghoebar, GM. Buccal bone thickness at dental implants in the maxillary anterior region with large bony defects at time of immediate implant placement: A 1-year cohort study. Clin Implant Dent Relat Res. 2019; 21: 73– 9.
21. Wang X, Ma J, Wang Y, He B. Bone repair in radii and tibias of rabbits with phosphorylated chitosan reinforced calcium phosphate cements. Biomater 2002; 23:4167- 76.
22. Nkenke, E,Neukam FW. Autogenous bone harvesting and grafting in advanced jaw resorption: morbidity, resorption and implant survival. Eur J Oral Implantol. 2014; 7; S203 – 17.
23. Kotsakis GA, Romanos GE. Biological mechanisms underlying complications related to implant site preparation. Periodontol 2000. 2022; 88:52-63.

24. Abdel-Fattah M Amer., et al. "Diode Laser Biostimulatory Effect on Dental Implant Inserted into Narrows Mandibular Ridges: Clinico-Radiographic Evaluation". Acta Scientific Dent Sci. 2021; 5:100-8.
25. Aimetti M, Mariani GM, Ferrarotti F, Ercoli E, Liu CC, Romano F. Adjunctive efficacy of diode laser in the treatment of peri-implant mucositis with mechanical therapy: A randomized clinical trial. Clin Oral Implants Res. 2019; 30:429-38.
26. Mohamed H, Kothayer M. Effect of LASER on Crestal Bone Loss Around Dental Implants Retaining Mandibular Overdenture. Egypt J Oral Maxillofac Surg. 2020; 11:142-9.
27. Bajaj S, Rani S, Issar G, Sethi U, Kumar S, Mishra S. Comparative evaluation of crestal bone levels around endosseous implants as influenced by conventional and diode laser during second-stage surgery in mandibular implant-supported overdenture: An in vivo study. J Indian Prosthodont Soc 2020; 20:52-60.
28. Mandić B, Lazić Z, Marković A, Mandić B, Mandić M, Djinić A, Miličić B. Influence of postoperative low-level laser therapy on the osseointegration of self-tapping implants in the posterior maxilla: a 6-week split-mouth clinical study. Vojnosanit Pregl. 2015; 72:233-40.
29. Bakry SA, Kamel HM. EVALUATION OF CRESTAL BONE CHANGES AROUND DELAYED IMPLANT IN RESPONSE TO DIODE LASER THEARAPY: A RANDOMIZED CONTROLLED CLINICAL TRIAL. Egypt Dent J. 2020; 66:841-51.
30. Aoki N, Kanayama T, Maeda M, Horii K, Miyamoto H, Wada K, Ojima Y, Tsuchimochi T, Shibuya Y. Sinus augmentation by platelet-rich fibrin alone: A report of two cases with histological examinations. Case Rep Dent. 2016; 2016:2654645.
31. Wu M, Chen G, Li YP. TGF-β and BMP signaling in osteoblast, skeletal development, and bone formation, homeostasis and disease. Bone Res. 2016; 4:16009.
32. Nedir R, Nurdin N, Khoury P, Bischof M. Short Implants Placed with or without Grafting in Atrophic Sinuses: The 3-Year Results of a Prospective Randomized Controlled Study. Clin Implant Dent Relat Res. 2016; 18:10-8.
33. Al-Maawi S, Becker K, Schwarz F, Sader R, Ghanaati S. Efficacy of platelet-rich fibrin in promoting the healing of extraction sockets: a systematic review. Int J Implant Dent. 2021; 7:117.
34. Miron RJ, Moraschini V, Fujioka-Kobayashi M, Zhang Y, Kawase T, Cosgarea R, et al. Use of platelet-rich fibrin for the treatment of periodontal intrabony defects: a systematic review and meta-analysis. Clin Oral Investig. 2021 ;25:2461-2478
35. Mumcu E, Beklen A. The effect of smoking on the marginal bone loss around implant-supported prostheses Tob Induc Dis. 2019; 17:43.
36. Barzilay I, Graser GN, Iranpour B, Proskin HM. Immediate implantation of pure titanium implants into extraction sockets of Macaca fascicularis. Part I: Clinical and radiographic assessment. Int J Oral Maxillofac Implants. 1996; 11:299-310.
37. Chen ST, Darby I. The relationship between facial bone wall defects and dimensional alterations of the ridge following flapless tooth extraction in the anterior maxilla. Clin Oral Implants Res. 2017; 28: 931-7.
38. Sennerby L, Andersson P, Pagliani L, Giani C, Moretti G, Molinari M, et al. Evaluation of a novel cone beam computed tomography scanner for bone density examinations in preoperative 3D reconstructions and correlation with primary implant stability. Clin Implant Dent Relat Res. 2015; 17:844-53.
39. Razavi T, Palmer RM, Davies J, Wilson R, Palmer PJ. Accuracy of measuring the cortical bone thickness adjacent to dental implants using cone beam computed tomography. Clin Oral Implants Res. 2010; 21: 718-25.
40. Kamburoğlu K, Murat S, Kılıç C, Yüksel S, Avsever H, Farman A, et al. Accuracy of CBCT images in the assessment of buccal marginal alveolar peri-implant defects: effect of field of view. Dentomaxillofac Radiol. 2014; 43:20130332.
41. Silva GAF, Faot F, Possebon APDR, da Silva WJ, Del Bel Cury AA. Effect of macrogeometry and bone type on insertion torque, primary stability, surface topography damage and titanium release of dental implants during surgical insertion into artificial bone. J Mech Behav Biomed Mater. 2021; 119:104515.
42. Kumar Ravishankar DR, Raghav T, Singh M, Singh MM. A Comparative Radiographic Evaluation of Crestal Bone Resorption in Single Implant versus Two Implant Retained Mandibular Overdentures–A Randomised Controlled Trial. EAS J Dent Oral Med. 2020; 2:173-8.
43. Oh TJ, Yoon J, Misch CE, Wang HL. The causes of early implant bone loss: myth or science? J Periodontol. 2002; 73:322-33
44. Meijer HJA, Slagter KW, Vissink A, Raghoebar GM. Buccal bone thickness at dental implants in the maxillary anterior region with large bony defects at time of immediate implant placement: A 1-year cohort study. Clin Implant Dent Relat Res. 2019; 21:73–9.
45. Cortese A, Pantaleo G, Amato M, Howard CM, Pedicini L, Claudio PP. Platelet-Rich Fibrin (PRF) in Implants Dentistry in Combination with New Bone Regenerative Flapless Technique: Evolution of the Technique and Final Results. Open Med (Wars). 2017; 12:24-32.