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Comparative Assessment of Change in Porphyromonas gingivalis levels, Crestal Bone Level and Stability of Immediate Implant with or without Laser Disinfection: An In-Vivo Study

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Research Article

Keywords: Immediate Implant, Diode Laser, P. gingivalis, Crestal Bone, Implant Stability, Real time Polymerase Chain Reaction

Posted Date: September 9th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10485175/v1

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Additional Declarations: No competing interests reported.

Abstract

Aim-

The aim of this study was to compare *Porphyromonas gingivalis* levels, crestal bone levels and stability of immediate implant placed with or without laser disinfection.

Materials and Method-

Sixteen teeth requiring extraction were randomly allocated to Group A (socket curettage) or Group B (laser disinfection) before immediate implant placement. GI and PI were recorded at baseline, 3, and 6 months. ISQ was measured immediately after implant placement and at 3 months. Crestal bone levels were evaluated immediately and at 3 and 6 months. mPI was recorded at 2 weeks, 3 and 6 months. Sub-gingival plaque samples were analyzed for *Porphyromonas gingivalis* at baseline and 3 months using RT-PCR.

Results-

Both groups showed significant improvement in plaque and gingival scores from baseline to 3 and 6 months ($p < 0.05$). Group B showed significant reductions in PI ($p = 0.01$), mPI ($p = 0.002$) and GI ($p = 0.05$) scores along with a significant decrease in *P. gingivalis* levels ($p = 0.01$) at 3 months. Implant stability improved significantly in both groups with no intergroup difference at 3 months. Mean change in mesial ($p = 0.04$) and distal ($p = 0.01$) crestal bone levels were significant from implant placement to 6 months favored Group B.

Conclusion-

The group receiving laser disinfection exhibited a marked reduction in *Porphyromonas gingivalis*, highlighting the strong antimicrobial efficacy of laser application. This was accompanied by acceptable implant stability and better preservation of crestal bone levels. These findings suggest that laser disinfection promotes favourable peri-implant outcomes and osseointegration, making it a beneficial adjunct in immediate implant therapy.

INTRODUCTION

Dental implant placement immediately into post-extraction sites has gained widespread acceptance owing to multiple benefits, such as shorter overall treatment time, fewer surgical procedures, enhanced patient comfort through a decreased number of clinical visits, optimal three-dimensional implant positioning and stabilization of the surrounding hard and soft tissues.[1] *Managutti et al* found favorable

outcomes with immediate implant placement when compared to delayed implant protocols.[2] *Corbella et al* stated that immediate implant placement following meticulous debridement and decontamination of both hard and soft tissue components of infected sockets, along with thorough removal of microbial debris, is essential for improved success rates.[3]

One of the disadvantages of immediate implant placement (IIP) is the possibility that residual infection within the extraction socket may contaminate the implant during the early healing phase.[4] *Luongo et al* documented a case in which an implant periapical lesion developed around an immediately placed implant, likely due to residual infection, resulting in implant failure, ultimately necessitating implant removal.[5]

Recent studies indicate that the microbiota associated with peri-implantitis is predominantly polymicrobial and anaerobic in nature.[6] Periodontal pathogens commonly associated with peri-implantitis include *P. gingivalis*, *T. forsythia*, *T. socranskii*, *S. aureus*, *S. intermedius*, *S. mitis*, and *H. influenzae*. These organisms constitute approximately 30.2% of the microbiota found in implants affected by peri-implantitis compared to 14.1% in clinically healthy implants.[7] In immediate implant placement, bacteria from peri-implant soft tissues or adjacent periodontal sites may contaminate the implant bed, impairing healing and osseointegration and reducing implant stability. Studies report that peri-implantitis plaque contains a high proportion of gram-negative anaerobic rods.[8] These gram-negative bacteria, particularly black-pigmented *Bacteroides* species are recognized as major contributors to the development of periodontal disease and are also found in significantly higher numbers at failing peri-implant sites.[9]

Thorough curettage of granulation tissue and complete removal of soft tissue remnants within and surrounding the extraction socket are essential to minimize inflammatory responses.[10] Debridement involves the elimination of bacteria and their associated irritants from the osteotomy site through copious irrigation using a syringe and/or internally irrigated drills during site preparation.[11] Various disinfection methods, such as prophylactic antibiotics and antiseptic irrigation, are used before immediate implant placement to reduce infection risk and decontaminate inaccessible areas. However, their effectiveness is limited against deep pigmented periopathogens. Novaes and Novaes reported successful immediate implant placement in teeth with periapical lesions when systemic antibiotics, thorough socket cleaning, and alveolar debridement are performed.[12] A systematic review by *Mickevicius et al* concluded that without thorough curettage of compromised sockets, adjunctive disinfection techniques were ineffective, and that local antibiotic application neither improved implant survival nor was routinely necessary.[13]

Schwartz et al observed that pathogenic bacteria may persist within extraction sites despite extensive irrigation performed during implant surgery, thereby serving as a potential source for early implant surface colonization.[14]

In recent years, the use of lasers has gained increasing popularity in the field of oral implantology.[15] Laser disinfection following mechanical debridement of periapical infections within extraction sockets, results in improved modulation of the dysbiotic microbial environment, which is predominantly controlled by anaerobic periodontopathogens such as *P. gingivalis*, *A. actinomycetemcomitans*, *P. intermedia* and *T. forsythia*. Consequently, effective socket disinfection remains a critical protocol for enhancing osseointegration and stability of immediate dental implants.[16] Diode lasers exhibit deeper tissue penetration and strong affinity for pigmented chromophores in periopathogens, enabling effective targeting of black-pigmented bacteria such as *P. gingivalis*. Bacterial destruction occurs mainly through photothermal effects and ROS generation, leading to irreversible cell damage.[17]

Bacterial colonization and its quantitative reduction can be evaluated using polymerase chain reaction (PCR) techniques. Real-time PCR (qPCR) is a molecular diagnostic method that monitors amplification of specific DNA sequences in real time, allowing both detection and quantification of target genes.[18]

Although laser therapy has demonstrated multiple benefits related to tissue regeneration, there remains limited evidence regarding its effectiveness in reducing bacterial colonization, particularly *P. gingivalis*, which is strongly implicated in the pathogenesis of peri-implantitis.[19]

Therefore, the present study was aimed to evaluate whether laser disinfection provides additional benefits in reducing *P. gingivalis* levels, improving implant stability, and preserving crestal bone levels when compared to conventional socket debridement without laser application.

MATERIALS AND METHOD

Study Design and Ethical statement-

This randomized, parallel group, single blinded, controlled clinical trial was carried out on patients visiting the outpatient clinic of Department of Periodontology and Oral Implantology. Ethical clearance was obtained from Institutional Ethics Committee. This study was also registered under Clinical Trial Registry India with registration number CTRI/2024/07/071443.

Subjects Recruitment and sample size calculation-

A total of 16 sites indicated for extraction were selected with equal distribution by chit system in both the groups. Group A included 8 sites where only curettage of the alveolar socket was done prior to immediate implant placement. Group B included 8 sites where Laser socket disinfection & laser flap debridement was done prior to immediate implant placement. The sample size calculation and power analysis was done using Software G*Power version 3.1.9.7. The actual power and the effect size are 97.34% and 2.098 respectively.

Inclusion and exclusion criteria-

Patients aged between 20 and 60 years, having hopeless teeth indicated for extraction including root fractures, mobile teeth, incomplete root canal treatment, having sufficient available bone in terms of quality and quantity as determined by cone beam computed tomography (CBCT), free from systemic diseases affecting gingival tissue and osseointegration and positive informed consent by the patient were included in this study. Patients with systemic diseases and hereditary disorders, sites with acute infection, history of smoking, alcohol, drug or tobacco abuse, pregnant or lactating women, patients with poor oral hygiene, implant insertion torque less than 35Ncm, insufficient bone volume or damage to cortical plate during extraction and patients with Para-functional habits were excluded from this study.

Standardized Parameters-

Clinical Parameters

Plaque accumulation was assessed using the Turskey-Gilmore-Glickman modification of the Quigley-Hein Plaque Index and Gingival health was examined using the Silness and Löe Gingival Index at baseline, 3 & 6 months, while Peri-implant plaque was evaluated using the modified plaque index of Mombelli et al. (1987)[19] at 2 weeks, 3 & 6 months in both groups. Implant stability was measured using Resonance Frequency Analysis (Penguin®) immediately after implant placement & 3 months with Implant Stability Quotient values recorded as the mean of readings from four different directions around each implant to ensure accuracy and reproducibility.

Microbiological Parameter

Quantitiative Real Time Polymerase Chain Reaction (qPCR) was carried out for P. gingivalis at Maratha Mandal's Central Research Laboratory, Belgaum, Karnataka. After supragingival cleaning of the sites with cotton pellets and drying of the supragingival area with a stream of air, subgingival plaque samples were taken by sterilized gingival curette from the deepest pocket of the tooth being extracted for immediate implant placement at baseline and after 3 months with the help of plastic curette from the deepest peri-implant area. Each sample was aseptically transferred into a sterile eppendorf tubes containing Tris-EDTA buffer solution medium (T.E. buffer) and stored at room temperature for further quantitative PCR analysis.

Radiological Parameter

Pre-operative CBCT was performed for implant planning, and intraoral periapical radiographs were obtained with grid using paralleling technique immediately after implant placement, 3 & 6 months post-operatively to assess mesial and distal crestal bone levels. Radiographs were taken at 70 kVp, 8 mA, and 0.63 seconds, and measurements were carried out using Image J software from the implant shoulder to the most coronal point of the alveolar crest. The image scale was calibrated using a known grid length,

following which linear measurements were recorded in millimeters on both mesial and distal aspects. Magnification error was corrected using the formula: actual implant length/radiographic implant length = actual crestal bone level/radiographic crestal bone level.

Surgical procedure-

Pre-procedural mouth rinsing with chlorhexidine was performed, followed by administration of local anesthesia using 2% lidocaine with 1:100000 epinephrine. A full-thickness flap was raised involving the mesial and distal aspects of the tooth, and atraumatic extraction was carried out using periotomes to preserve the buccal plate and surrounding tissues. In Group A, socket curettage was performed using bone curettes prior to immediate implant placement (Figure-1), whereas in Group B, diode laser–assisted socket disinfection and flap debridement were carried out before implant placement (Figure-2).

Laser Specifications- Laser socket disinfection[20] was performed using a 940-nm diode laser with an uninitiated 300-µm fiber tip at 3 W in continuous mode for 10 seconds, moving circumferentially from the base of the socket upward in contact mode.

Laser soft tissue debridement[21] was carried out using the same wavelength at 1.5 W in contact mode with the fibre held at a 45° angle to the inner flap surface, applying horizontal overlapping strokes on the facial and palatal flaps for approximately 10 seconds. Following implant insertion, a smart peg was attached and implant stability was assessed using Resonance Frequency Analysis (Penguin®). Customized healing abutments were placed and the flap was sutured with 3 – 0 Mersilk suture.

Real-time PCR Procedure-

Following set of PCR primers were used which are specific to 16SrRNA gene of *P. gingivalis*-

Forward primer: AGG CAG CTT GCC ATA CTG CG

Reverse primer: ACT GTT AGC AAC TAC CGA TGT

Real-time qPCR amplification and detection were performed with the Real-time thermal cycler (QuantStudio™ 5, Applied Biosystems) using a 96-well format. PCR reactions were performed in a total volume of 20µl containing 2 µl of template DNA, 10µl of TB Green Premix Ex Taq (Tli RNaseH Plus) (Takara Bio inc., Kusatsu, Japan), 8 pm/ µl of each of the *P. gingivalis*-specific primers (TB Green Premix Ex Taq (Tli RNaseH Plus). qPCR reaction conditions were 95°C for 30 sec, and 40 cycles of 95°C for 20 sec, 61°C for 30 sec and 72°C for 30 sec[22].

Post Surgical phase-

Oral hygiene instructions were given. Tab Augmentin 625mg, combination of Acelofenac 100mg + Paracetamol 325 mg for 5 days, and chlorhexidine mouth rinse for 7 days were advised. The wound was

monitored for any signs of infection and pain. The sutures were removed 10 days after the surgery. Following a three-month healing period, the PFM crowns were designed and delivered to the patients.

Statistical Analysis-

The data was entered into Microsoft Excel XP software program. Statistical analysis was done by Statistical Package for the Social Sciences (SPSS) software package (SPSS 16 Inc, Chicago IL, USA). For normal data, parametric test Independent t- test for intra group comparisons, repeated measures of ANOVA followed by Bonferroni test was used among the study population. The significance of skewed data was tested by non-parametric test. For inter group comparison, Krushkal wallis test and Mann whitney U test and for intra group comparison, Wilcoxon Signed Rank test was used. The level of significance was set at $p < 0.05$.The β error and power of study was 5% and 95% respectively.

RESULTS

The mean age was 44.00 ± 15.26 years in group A and 46.25 ± 10.09 years in group B that did not differ significantly in both the groups. In group A, 12.5% females and 87.5% males were found whereas in group B, all males were present meant that sex ratio was homogenous for both the groups. All patients participated until the end of the study with no clinical dropout reported and showed good compliance in oral hygiene maintenance. No complication was recorded in any of the cases. Healing, in general, was uneventful with minimal discomfort to all the patients.

Plaque scores showed statistically significant reductions from baseline to 3 and 6 months in both groups (Table-1). Intergroup comparison revealed significantly lower plaque scores in Group B at 3 months, while baseline and 6-month values were comparable (Table-2).

Gingival inflammation decreased significantly from baseline to 3 and 6 months in both groups (Table-1). Intergroup comparison showed a significant difference at 3 months, with Group B demonstrating better gingival health. No significant difference was observed at baseline and 6 months (Table-2).

Group A showed no significant change over time in terms of Modified plaque index. Group B demonstrated a significant reduction from 2 weeks to 3 months and 6 months (Table-1). Intergroup comparison showed a significant difference only at 3 months, favoring Group B (Table-2).

Implant stability increased significantly from immediate placement to 3 months in both groups (Table-1). However, intergroup comparison showed no statistically significant difference between the groups at either time interval (Table-2).

On intragroup comparison, Group A showed statistically significant reduction in mesial crestal bone level whereas Group B showed statistically non-significant reduction from immediate placement to 3 and 6 months (Table-3). Intergroup comparison revealed insignificant differences between the groups immediately after implant placement as well as at 3 and 6 months. The mean change in mesial crestal bone level was not statistically significant from immediate placement to 3 months between the groups.

However mean change was statistically significant from immediately after implant placement to 6 months between the groups, favouring Group B (Table-4).

On intragroup comparison, both the groups showed statistically significant reduction in distal crestal bone level from immediate implant placement to 3 and 6 months (Table-3). Intergroup comparison showed no significant difference between the groups at immediate placement as well as at 3 and 6 months. However, mean change in distal crestal bone level was statistically significant from immediately after implant placement to 3 as well as 6 months, which was in favour of Group B (Table-4).

Group A showed increase in P. gingivalis levels though statistically not significant whereas Group B demonstrated a significant reduction from baseline to 3 months. Intergroup comparison showed significant difference at 3 months, with lower P. gingivalis levels in Group B (Table-5).

Table-1 Intragroup comparison of Clinical Parameters

PLAQUE INDEX	Group	Time Period	Mean Change ± SD	P value
	Group A	Baseline-3 Months	0.96 ± 0.50	0.001*
		Baseline-6 Months	0.70 ± 0.50	0.005*
	Group B	Baseline-3 Months	1.56 ± 0.51	0.000*
		Baseline-6 Months	1.21 ± 0.44	0.000*
GINGIVAL INDEX	Group A	Baseline-3 Months	0.84 ± 0.44	0.001*
		Baseline-6 Months	0.68 ± 0.36	0.001*
	Group B	Baseline-3 Months	1.37 ± 0.79	0.002*
		Baseline-6 Months	0.88 ± 0.44	0.001*
MODIFIED PLAQUE INDEX	Group A	2 Weeks-3 Months	0.25 ± 0.70	0.35
		2 Weeks-6 Months	0.50 ± 0.92	0.17
	Group B	2 Weeks-3 Months	1.12 ± 0.64	0.002*
		2 Weeks-6 Months	0.50 ± 0.53	0.03*
*Significant ($p < 0.05$)				

IMPLANT STABILITY QUOTIENT	Group A	Immediately after implant-3 Months	4.87 ± 3.31	0.004*
	Group B	Immediately after implant-3 Months	7.12 ± 5.33	0.007*
*Significant ($p < 0.05$)				

Table-2 Intergroup comparison of Clinical Parameters

PLAQUE INDEX	Time Period	Group	Mean ± SD	P value
	Baseline	Group A	1.73 ± 0.69	0.62
		Group B	1.89 ± 0.63	
	3 Months	Group A	0.76 ± 0.31	0.01*
		Group B	0.33 ± 0.23	
	6 Months	Group A	1.02 ± 0.63	0.18
		Group B	0.68 ± 0.25	
GINGIVAL INDEX	Baseline	Group A	1.71 ± 0.54	0.58
		Group B	1.94 ± 0.99	
	3 Months	Group A	0.87 ± 0.32	0.05*
		Group B	0.57 ± 0.45	
	6 Months	Group A	1.03 ± 0.58	0.93
		Group B	1.06 ± 0.61	
MODIFIED PLAQUE INDEX	2 Weeks	Group A	1.25 ± 0.46	1.00
		Group B	1.25 ± 0.46	
	3 Months	Group A	1.00 ± 0.53	0.002*
		Group B	0.12 ± 0.35	
	6 Months	Group A	0.75 ± 0.46	1.00
		Group B	0.75 ± 0.46	
IMPLANT STABILITY QUOTIENT	Immediately after implant	Group A	71.75 ± 2.86	0.13
		Group B	67.38 ± 7.28	
	3 Months	Group A	76.62 ± 3.33	0.27
		Group B	74.50 ± 4.03	
*Significant ($p < 0.05$)				

Table-3 Intragroup comparison of Mesial and Distal Crestal Bone Levels (in mm)

MESIAL CRESTAL BONE LEVEL	Group	Time Period	Mean Change ± SD	P value
	Group A	Immediately after implant(Baseline)-3 Months	-1.95 ± 1.13	0.01*
		Baseline-6 Months	-1.96 ± 1.08	0.01*
	Group B	Baseline-3 Months	0.75 ± 1.62	0.17
		Baseline-6 Months	-0.82 ± 1.41	0.12
DISTAL CRESTAL BONE LEVEL	Group A	Baseline-3 Months	-2.57 ± 1.78	0.01*
		Baseline-6 Months	-2.68 ± 1.88	0.01*
	Group B	Baseline-3 Months	-0.61 ± 0.70	0.05*
		Baseline-6 Months	-0.67 ± 0.75	0.05*

*Significant ($p < 0.05$)

Table-4 Intergroup comparison of Mesial and Distal Crestal Bone Levels (in mm)

MESIAL CRESTAL BONE LEVEL	Time Period	Group	Mean ± SD	P value
	Immediately after implant (Baseline)	Group A	1.67 ± 1.44	0.20
		Group B	0.83 ± 1.33	
	3 Months	Group A	-0.27 ± 1.46	0.56
		Group B	0.08 ± 1.83	
	6 Months	Group A	-0.28 ± 1.43	0.56
		Group B	0.01 ± 1.95	
	Mean Change (Baseline-3 months)	Group A	-1.95 ± 1.13	0.06
		Group B	-0.75 ± 1.62	
	Mean Change (Baseline-6 months)	Group A	-1.96 ± 1.08	0.04*
		Group B	-0.82 ± 1.41	
DISTAL CRESTAL BONE LEVEL	Immediately after implant (Baseline)	Group A	2.28 ± 1.95	0.20
		Group B	0.95 ± 1.50	
	3 Months	Group A	-0.28 ± 1.46	0.42
		Group B	0.33 ± 1.36	
	6 Months	Group A	-0.40 ± 1.46	0.40
		Group B	0.27 ± 1.43	
	Mean Change (Baseline-3 months)	Group A	-2.57 ± 1.78	0.01*
		Group B	-0.61 ± 0.70	
	Mean Change (Baseline-6 months)	Group A	-2.68 ± 1.88	0.01*
		Group B	-0.67 ± 0.75	

*Significant ($p < 0.05$)

Table-5 Intra-group and Intergroup comparison of levels of P. gingivalis (Log Transformed Data)

Group A	At Baseline	At 3 Months	Intragroup Comparison (P value)
	3.28 ± 0.31	**4.07 ± 1.03**	**0.07**
Group B	3.32 ± 0.32	3.01 ± 0.28	0.001*
Intergroup comparison (P value)	0.76	0.01*	

*Significant ($p < 0.05$)

DISCUSSION

The present study highlights the pivotal role of laser disinfection in enhancing peri-implant outcomes by modulating bacterial load and crestal bone stability. A comparative evaluation was performed between immediate implant placement with and without laser disinfection. Group A underwent conventional curettage of the alveolar socket prior to immediate implant placement, whereas Group B received laser-assisted socket disinfection along with laser-assisted flap debridement before implant placement. A total of 16 implants were placed, with 8 implants in each group. All enrolled patients adhered to scheduled maintenance and post-operative follow-up visits.

Effective decontamination of the extraction socket reduces the microbial load, eliminates residual biofilm and minimizes the risk of persistent infection, thereby creating a biologically favorable environment for osseointegration. It also helps in preserving surrounding hard and soft tissues, ultimately improving implant stability and long-term outcomes.

In the present study, PI decreased significantly in both groups from baseline to 3 and 6 months, with a greater reduction observed in Group B. This improvement may partly reflect enhanced oral hygiene due to patient motivation during follow-up visits. The lower PI scores in Group B may also be attributed to the bactericidal and photodisruptive effects of laser therapy. Similar findings were reported by *Birang et al. (2012)*[23] whereas *Atieh et al. (2022)*[24] reported no significant advantage of diode lasers in plaque reduction.

Both groups in the current study showed significant reductions in GI scores from baseline to 3 and 6 months, indicating improvement in gingival health. However, Group B demonstrated significantly lower scores compared to Group A. This improvement may be related to better plaque control and the adjunctive effect of laser therapy, which can enhance soft tissue healing through modulation of inflammatory mediators and increased fibroblast and vascular activity. Similar observations have been reported by *Berglundh (2011)*[6] and *Zoe et al. (2024)*[25], although *Atieh et al. (2022)*[24] found no additional benefit of diode lasers in reducing gingival inflammation.

In the present study, mPI showed non-significant reduction in Group A, whereas Group B demonstrated a significant decrease from 2 weeks to 3 and 6 months. Intergroup comparison revealed significantly lower mPI scores in Group B at 3 months, which may be explained by the antimicrobial effects of laser irradiation in reducing peri-implant biofilm formation. Previous studies by *Mombelli et al. (1987)*[19] and *Anand et al. (2012)*[26] also reported less mPI scores around successful implants.

ISQ values increased in both groups from implant placement to 3 months, indicating successful osseointegration and favorable bone remodeling. Although Group B showed greater improvement, the difference between groups was not statistically significant. These findings are consistent with *Rowan et al. (2015)*[27], who reported that ISQ values above 65 indicate adequate implant stability. *Fahim et al (2023)*[28] also suggested that laser therapy may enhance bone remodeling and vascular activity, thereby supporting implant stability.

Crestal bone remodeling is expected following implant placement; however, excessive bone loss may compromise implant success. In the present study, mesial and distal crestal bone levels were evaluated using grid-based IOPA radiographs with ImageJ analysis. Group A showed significant reductions in both mesial and distal crestal bone levels, whereas Group B demonstrated smaller and mostly non-significant changes. Although intergroup differences in mean values were not significant, the mean change in mesial crestal bone level favoured Group B at 6 months whereas distal crestal bone level favored Group B both at 3 and 6 months. This effect may be attributed to laser-assisted curettage of the tissues surrounding the extraction socket, wherein the bactericidal effect and deeper penetration of laser irradiation facilitate effective decontamination. Similar findings have been reported by *Gulati et al. (2020)*[29], who observed reduced crestal bone loss in laser-treated implant sites.

In the current study, RT-PCR analysis showed a non-significant increase in Group A, whereas Group B demonstrated a significant reduction in bacterial levels at 3 months. Intergroup comparison also showed significantly lower counts in Group B. The enhanced microbial reduction may be associated with the potent antimicrobial action of laser therapy, which effectively reduces the microbial load at the treatment site, thereby creating a more favorable environment for tissue stability and implant integration. Similar reductions in peri-implant microbial load following laser therapy have been reported by *Nerkar et al. (2024)*[30], *Nastych et al. (2020)*[31], *and Galassi et al. (2012)*[32].

In this study, customized gingival formers were placed immediately following implant placement, eliminating the need for second-stage surgery and reducing patient discomfort. This approach allowed soft tissue maturation prior to final prosthesis fabrication. *Mihali et al (2018)*[33] reported significant advantages of customized healing abutments over conventional designs in maintaining emergence profile during immediate implant placement.

Few limitations of this study include a relatively small sample size, lack of site-specific implant placement, reliance on IOPA rather than CBCT for bone assessment, and short follow-up duration. Future

studies with larger sample sizes, longer follow-up periods, and three-dimensional imaging are recommended to validate these findings.

This study highlights the importance of thorough decontamination of both hard and soft tissues in and around the sockets which is essential for achieving successful immediate implant placement. This enhanced antimicrobial effect of laser contributes to improved preservation of crestal bone levels, reduction in P. gingivalis levels which may decrease the incidence of post-surgical infections and leads to higher implant survival rates in cases of immediate implant placement.

Future directions indicate that the antimicrobial potential of laser therapy could serve as an effective alternative to postoperative antibiotics, helping to minimize their use and reduce the risk of developing antibiotic resistance over time.

CONCLUSION

Within the limitations of this in-vivo study, it can be concluded that the adjunctive use of laser socket disinfection and laser flap debridement during immediate implant placement offers significant advantages over conventional socket debridement, in terms of decrease in P. gingivalis levels in peri-implant tissues and better preservation of crestal bone levels.

Declarations

FUNDING-

The authors received no financial support, grants or other funding for the preparation of this manuscript.

Author Contribution

R.C. and P.S. designed methodology. Experiments were carried out by M.V. Analysis was done by D.C.S. and S.M. Conceptualization, investigation, supervision, editing, and validation were performed by all authors.

Acknowledgement

RT-PCR in this study was carried out at Maratha Mandal's Central Research Laboratory, Belgaum, Karnataka.

Data Availability

The data that support the findings of this study are available on request from the corresponding author.

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Figures

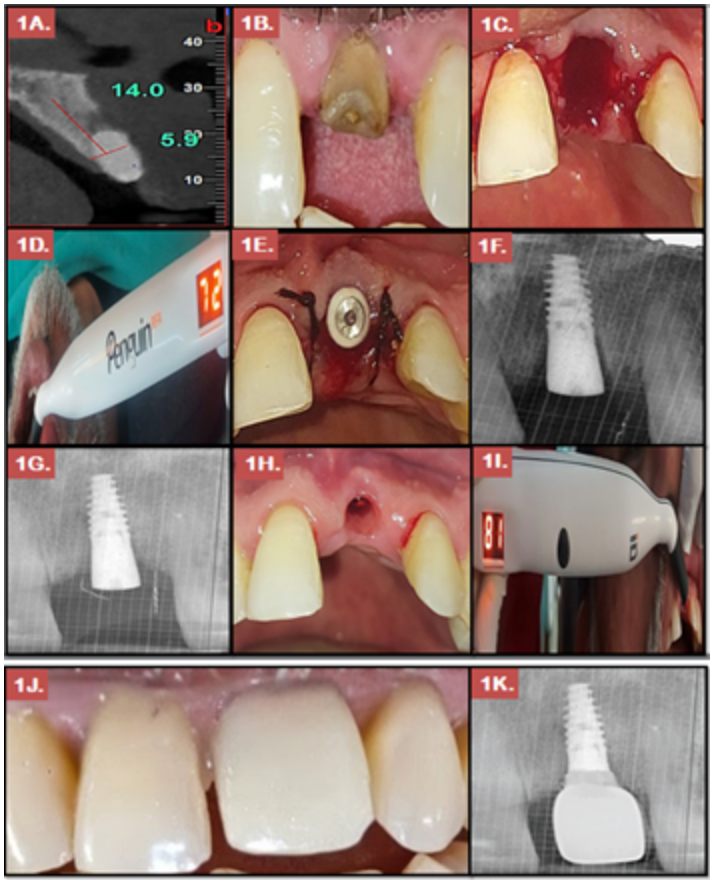


Figure 1

A. Pre-operative CBCT irt 21; B. Pre-operative view; C. Socket immediately after extraction and curettage; D. ISQ immediately after implant placement; E. Implant with customize healing abutment and suturing; F.

IOPA immediately after implant placement; G. IOPA at 3 months; H. Post implant healing at 3 months; I. ISQ at 3 months; J. Prosthesis irt 21; K. Post-operative IOPA at 6 months

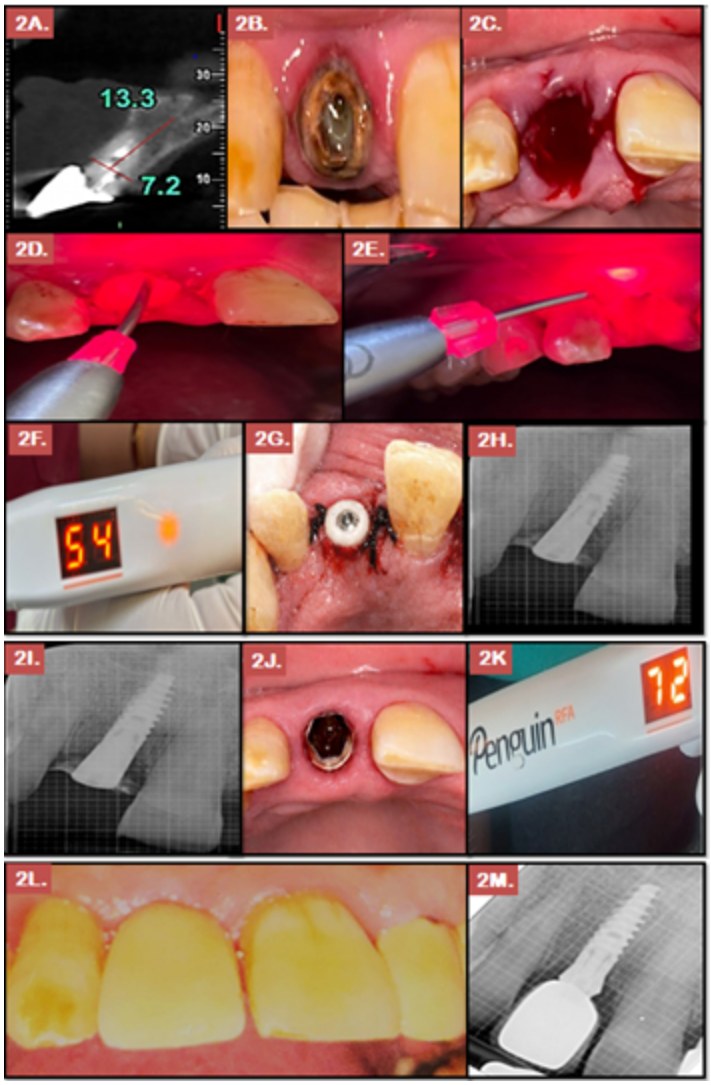


Figure 2

A. Pre-operative CBCT irt 11; B. Pre-operative view; C. Socket immediately after extraction; D. Laser socket disinfection; E. Laser flap debridement; F. ISQ immediately after implant placement; G. Implant with customize healing abutment and suturing; H. IOPA immediately after implant placement; I. IOPA at 3 months; J. Post implant healing at 3 months; K. ISQ at 3 months; L. Prosthesis irt 11; M. Post-operative IOPA at 6 months

Consort Chart-

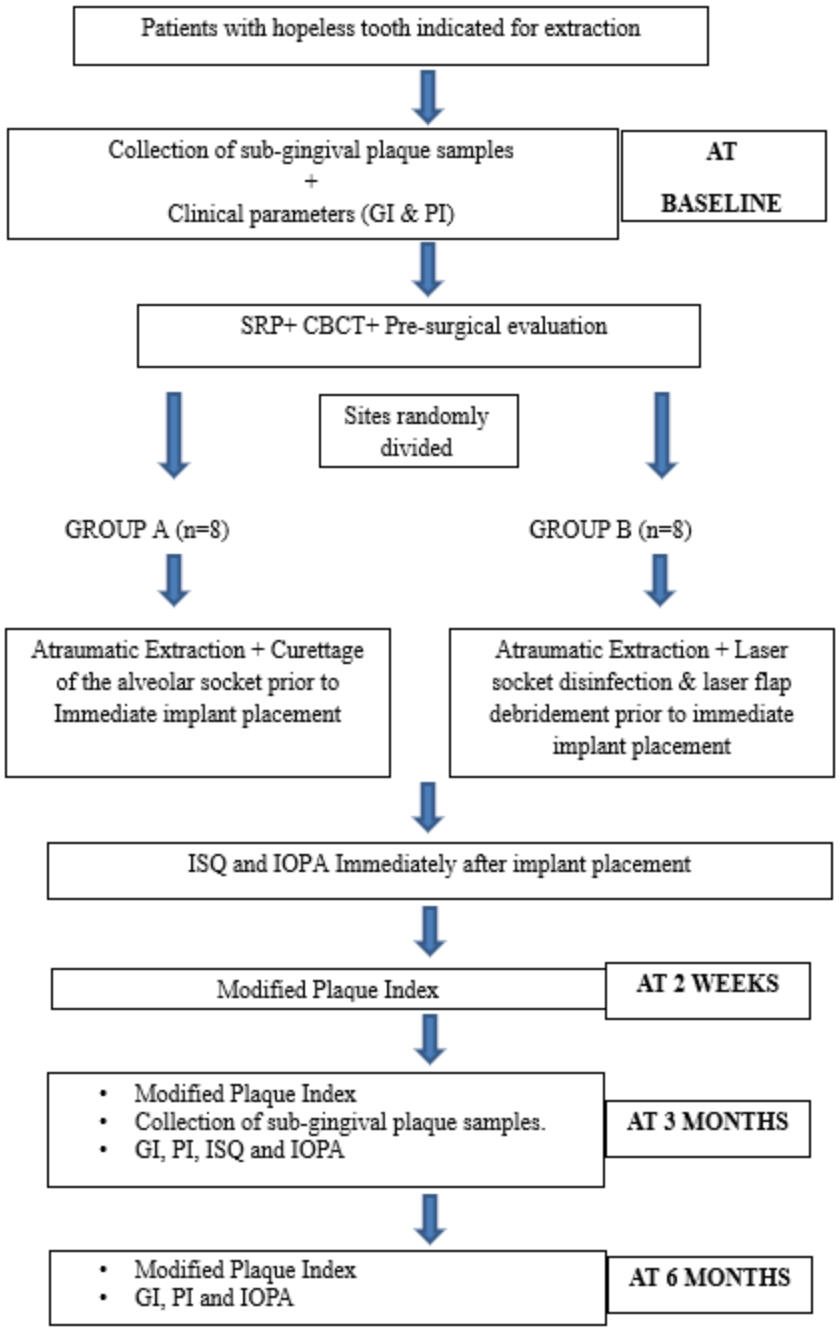


Figure 3

Unnumbered image in the MATERIALS AND METHOD section.